THE

AMERICAN NATURALIST

VOL. XXXIV. *November, 1900.* NO. 407.

A SINGULAR ARACHNID (KŒNENIA MIRABILIS GRASSI) OCCURRING IN TEXAS.[1]

WILLIAM MORTON WHEELER.

IN 1886 Battista Grassi[2] described as the representative of a new order a remarkable arachnid which he found near the base of Mt. Ætna in the campagna of Catania, Sicily. Grassi's description was imperfect and seems to have excited little interest in his discovery till Dr. H. J. Hansen in 1893 collected a number of specimens of the same species in southern Italy (near Palmi and Scilla in Calabria) and together with Dr. W. Sörensen published a careful description of the external anatomy, with some good figures of the animal.[3]

During the past spring, while collecting specimens of Iapyx, Campodea, and Scolopendrella, in the vicinity of Austin, Texas, I

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 8.

[2] I Progenitori dei Miriapodi e degli Insetti. Mem. V. Intorno ad un nuovo Aracnide Artrogastro (Kœnenia mirabilis) rappresentante di un nuovo ordine (Microthelyphonida), *Bull. d. Soc. entom. Italiana*, pp. 153–172. Anno 18. Firenze, 1886.

[3] The Order Palpigradi Thor. (Kœnenia mirabilis Grassi) and its Relationship to the other Arachnida, *Entomol. Tidskr.*, pp. 223–240. Arg. 18 H. 4, 1897. Taf. IV.

found a minute arachnid which at first sight resembled the whip-tailed scorpions (Thelyphonus), but on closer inspection proved to be something very different. Text-books were consulted in vain, with the single exception of Lang's *Vergleichende Anatomie,* which put me on the track of the Microthely-

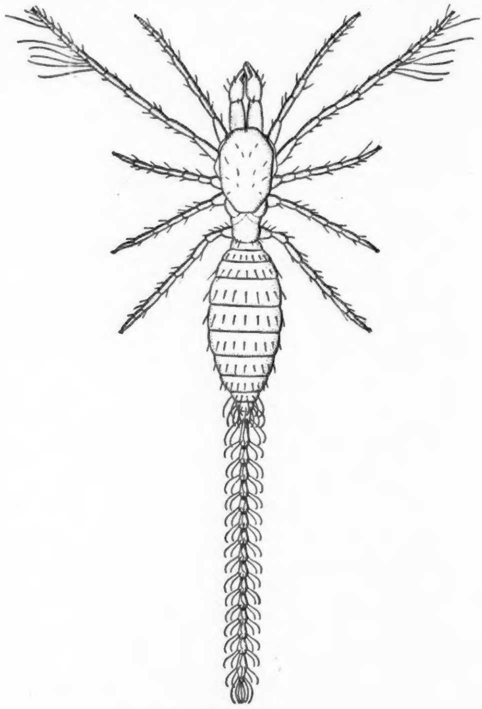


FIG. 1.

phonida of Grassi. Then, through the kindness of Drs. Hansen and Sörensen, I received a copy of their paper on *Kœnenia mirabilis.* To my surprise the Texan form proved to be identical with the Sicilian species!

In the following pages I shall consider, first, the external structure and systematic affinities of Kœnenia; second, its habits and habitat; and, third, its singular geographical distribution. If I repeat many of the statements in Hansen

and Sörensen's paper, this is because I have confirmed nearly all of their observations, published in a journal that may not be accessible to the reader, and because I am able to add a few facts of interest. An account of the internal anatomy, by Miss Augusta Rucker and myself, is reserved for future publication.

The observations of Grassi and Hansen and Sörensen refer only to the female Kœnenia, as the male was quite unknown to these investigators. In more than a hundred specimens I find only one which may, perhaps, be the male of this arachnid. To this I shall return in the sequel, after describing the female.

The general appearance of the female is correctly shown in Fig. 1, although in life the first pair of appendages, the cheliceræ, have their chelæ bent down so that they are not visible from above, and the caudal filament, or flagellum, is turned up over the back, or at least carried obliquely upwards. The length of the body varies from .7 to 1.25 mm.; the length of the caudal flagellum nearly equals that of the body. The animal is of a translucent white color except for the blades of the cheliceræ, which have the yellow tint of thickened chitin. The general chitinous integument is very thin and transparent, scarcely differing in thickness in the segmental and intersegmental, and on the dorsal and ventral regions of the body. The body and limbs are sparsely covered with bristles, which have a characteristic arrangement. They are delicately plumose under a high magnification.

The trunk proper consists of the head, thorax, and abdomen. The head, comprising at least four segments, as indicated by its four pairs of appendages, is covered dorsally with an elongate octagonal cephalic plate, or shield. This is broadest in the region of the coxæ of the third pair of limbs. It is abruptly declivous in front to the insertions of the cheliceræ. There are no traces of eyes, but Hansen and Sörensen have discovered two pairs of minute sense organs "as if in compensation" for the lack of visual structures.[1] "The foremost of these couples is situated in the median line of the body and on

[1] *Loc. cit.*, pp. 230, 231.

the front of the head, close above the first pair of limbs (cheliceræ); it consists of two flat, lancet-shaped bodies, which by a common basal part are attached to the head, against which they are pressed. The second couple forms two blades, which are placed close up to the sides of the head above the coxæ of the second pair of limbs, and which, though deviating somewhat in shape, in quality very much resemble the first couple of blades; they turn, at least when in repose, horizontally forward and outward. As they are articulated to the head, it is not unlikely that they can move. Morphologically they are hairs." Hansen and Sörensen do not pretend to have demonstrated the sensory function of these structures.

The Danish investigators have also given an accurate account of the mouth of Kœnenia.[1] "It is simpler than in any other arachnid, nay, than in almost all other Condylopods, no limbs at all participating in its forming, and we are of opinion that in this respect the mouth of Kœnenia, simple and plain as it is, presents great interest. It has the shape of a downward sloping protruding knot, and its opening consists of a relatively large split extending not quite up to the base of the mouth eminence. Seen from below, this split is slightly crescent-shaped and curves towards the front. It is bordered by two flaps which along its margins are furnished with a rather strongly chitinized "list" or frame, which seems to become somewhat weaker towards the corners of the mouth. The foremost or uppermost of these flaps no doubt constitutes the organ which in other Arachnida one of us (William Sörensen) calls the labrum (or, when divided into two parts, the clypeus and the labrum), but which otherwise (according to the different authors) goes by rather varying names (rostrum, epistoma, camerostoma). . . . We entertain some doubts as to how the lower or hindermost flap is to be understood from a morphological point of view. So for the present we will call it *hypostoma*, as we consider this name morphologically tolerably indifferent. It is furnished outwardly with very tiny backward turning hairs placed somewhat less close together than those on the labrum. The labrum, as well as the hypostoma, is

[1] *Loc. cit.*, pp. 226, 227.

movable, so as to allow the mouth to open and close. The muscles, which, by the bye, we have not examined more closely, are very strong."

The thorax, which is quite distinct from the head, consists of two separate segments, each bearing a pair of limbs. In this respect Kœnenia resembles the Tartarides and Solifugæ, the only other arachnids with a bisegmental thorax.

The six pairs of limbs are, with the exception of the first pair, or cheliceræ, of a remarkably simple structure. Even the cheliceræ are of a primitive type, in that they consist of three joints. They are said by Hansen and Sörensen to "correspond entirely with the type appearing in the Opiliones," except in their minuter characters. The insertions of their long and powerful first joints are slightly to the sides of the mouth; a very significant fact, since in all the higher Arachnida these organs are definitely preoral. The second and third joints of each chelicera form a pair of pinchers. Each of these joints is furnished with a dense series of eight slender, pointed teeth.

The second to sixth pairs of appendages have essentially the same simple type of structure, although the pairs differ in length and in the number of joints. The formula of their lengths is as follows:

$$3 > 6 > 2 > 5 > 4.$$

The second pair have nine joints, the third twelve, the fourth and fifth each seven, the sixth eight joints. All the legs terminate in two claws and a curved pseudonychium. All are provided with a coxa, trochanter, and femur. The third to sixth pairs have a separate patella and tibia, but these two joints are represented by a single piece in the second pair. "The metatarsus is two-jointed in the second pair of limbs, four-jointed in the third pair, and undivided in the fourth, fifth, and sixth pairs." The "tarsus is three-jointed in the second and third pairs of limbs, one-jointed in the fourth and fifth, two-jointed in the sixth."[1]

Although the second to sixth pairs of limbs are all used in

[1] Hansen and Sörensen, *loc. cit.*, p. 230.

running, the very long third pair are usually held aloft like antennæ when the animal is not disturbed and is moving about slowly. Some of the metatarsal and tarsal joints of this pair of appendages are provided with very long, delicate hairs of uniform thickness throughout. They are very probably sense-hairs (possibly auditory in function, as suggested by Hansen and Sörensen).

Between the insertions of the legs the ventral surface of the head and thorax presents a series of sternal plates to which the Danish arachnologists have called particular attention. The lower surface of the head has two of these plates, a larger anterior one just behind the mouth and corresponding to the second and third pairs of appendages, and a smaller piece corresponding to the third pair of limbs. Farther back there are two more sternal plates, one to each of the thoracic segments. The condition of the sternal apparatus of the head is emphasized "as a curiosity, as it is quite unique in Arachnida, which otherwise show no trace of independence in the segments constituting the head." [1]

The abdomen is elongate elliptical in outline, without any traces of dorso-ventral flattening, and consists of eleven segments. The first is short and narrow, and on this account may be readily overlooked. The ninth, tenth, and eleventh are very much narrower than the preceding segments. The last bears the anus on its ventral surface. To its posterior surface the caudal flagellum is attached. The dorsal surfaces of the abdominal segments each presents a single row of bristles which are inserted rather far apart and near the middle of their respective segments.

Hansen and Sörensen have failed to give a satisfactory account of the ventral surface of the abdomen. The conditions are not so easily studied as might at first sight be supposed. Nor am I certain that my analysis of this region is complete, as my specimens differ considerably in the clearness with which they show certain structures, notably the complicated valves surrounding the genital orifice. I am of the opinion that segments two to six are each provided with a

[1] Hansen and Sörensen, *loc. cit.*, p. 226.

pair of appendages, presumably the serial homologues of the cephalic and thoracic limbs. The appendages of the second and third segments have come together in the median line to form four peculiar setigerous valves surrounding the genital orifice lying between these segments. The shape of the valves and the characteristic arrangement of their bristles are shown in Fig. 2. The anterior pair, which I regard as the appendages of the first segment, are arcuate and closely applied to each other in the mid-ventral line. Their posterior edges are raised on either side into six papillæ, each capped with a strong bristle. The posterior pair are flattened and enclose the orifice of the chitinous genital conduit between their bases. Their posterior edges are fringed with a series of graduated bristles. A profile view of the abdomen shows that the genital duct runs forward into the second abdominal segment. Thus Kœnenia would seem to agree with other Arachnida in having the reproductive orifice on the second abdominal segment.

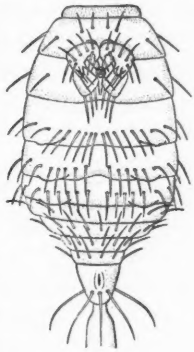


Fig. 2.

The ventral portions of the fourth, fifth, and sixth segments are nearly alike in structure. Each is provided with a single row of powerful bristles, which, though more or less interrupted in the median line, are nevertheless far more closely aggregated than those on the dorsal surface of the corresponding segments. On either side near the posterior edge of the segment there is a flap, the exact outline of which is not so clear as represented in Fig. 2. In many specimens a very delicate sac may be found evaginated from under the flap on all three segments. These sacs are in all probability lung-books. They appear to be the only respiratory organs of Kœnenia, apart from the delicate integument, which, in so small an animal, must of itself nearly suffice for respiratory purposes. I have had no better success than Grassi and Hansen and Sörensen in finding any traces of tracheæ. If I am correct in regarding the above-described sacs as lung-books,

they must represent these organs in an extremely simple form, in a form, moreover, which strongly suggests their origin from invaginated appendages serially homologous with those of the cephalic and thoracic segments. Whether these delicate organs may be everted by blood pressure and withdrawn by muscular action, like the collophoral tubes of the Collembola and the eversible sacs of Thysanura (Machilis, *e.g.*), remains to be determined. If this is the case, the hedge of bristles in front of the lung-book flap would seem to have a definite protective function.

Another lacuna in the observations of Hansen and Sörensen refers to the caudal flagellum. According to Grassi this organ contains altogether thirteen or fourteen joints. The greatest number of joints present in any of Hansen and Sörensen's specimens was nine, and on Grassi's authority they have added five joints of the same structure in fainter outline to the flagellum in their Fig. 1, Taf. IV. The flagellum is very easily broken, even after the animals have been transferred entire to alcohol, so that in upwards of a hundred specimens I found the structure complete in only ten individuals. Eight of these had fifteen, one had fourteen, and one had only eleven joints in the flagellum. There could be no doubt that in all these cases the flagellum was complete, as the terminal joint ends in a point and is longer and of a different shape than the preceding joints (Fig. 1). In my specimens, joints one to eleven have the structure described by Hansen and Sörensen.[1] Each "is fusiform, as if composed of two truncate cones, one long, the other short, united at their base, and adorned with two rings of backward-turning setiform hairs. In the foremost ring, situated on the widest part of it, we find, where we have been able to count the number, eight long, slightly curved hairs; in the hindmost terminal ring, sixteen much shorter, thinner, and less curved ones." In my specimens the posterior circlet of appressed bristles is lacking on the twelfth, thirteenth, and fourteenth joints. The terminal joint is twice as long as any of the preceding, fusiform in shape, and provided with two circlets of long, curved bristles.

[1] *Loc. cit.*, p. 233.

So much for the description of the female of *Kœnenia mirabilis.* From this description a single specimen among my material differs so much that I am compelled to regard it either as the hitherto unknown male of Grassi's species or as an entirely new form. I choose the former alternative, since the differences are confined, so far as I am able to determine, to size, the structure of the genital valves, and the caudal flagellum. The specimen is only .5 mm. in length. The genital valves, seen in profile in Fig. 3, certainly have a very different shape from those of the female, although I am unable to form a clear conception of their structure. The caudal flagellum, represented in Fig. 4, consists of only six joints of gradually decreasing size. There are only six bristles in the larger circlet of each joint, and the smaller circlet of appressed bristles is present only on joints one to four. In addition to the larger bristles, joints three to six have a number of minute scattered hairs. Of course we may consider the possibility of an abbreviated regeneration of the easily broken caudal flagellum, both in this specimen and in the case of the two above-mentioned females, with eleven and fourteen joints respectively. I am certain, however, that this six-jointed flagellum cannot represent merely a young stage in the development of the fifteen-jointed flagellum of the female, for I have seen several young female specimens of about the same size (.5–.7 mm.) with a large portion of the caudal filament, eight to ten joints, of the normal form.

Fig. 3.

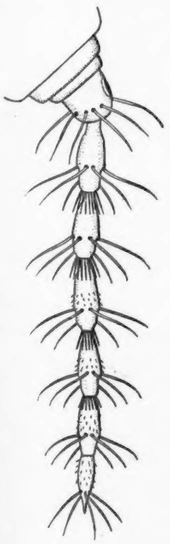


Fig. 4.

From the description of Kœnenia we pass to a consideration of its affinities. Grassi established it as the type of a distinct arachnid order, which he designated as *Microthelyphonida,* a term somewhat lengthy, to be sure, but nevertheless suggesting the small size of the

animal and its unmistakable resemblance to Thelyphonus, the whip-tailed scorpion. Without differing to an appreciable extent from Grassi in his conception of the taxonomic importance of Kœnenia, Thorell[1] has seen fit to change the name of the new order to *Palpigradi.* Hansen and Sörensen have adopted this name and have abandoned Grassi's. It would seem, however, that notwithstanding the aptness and brevity of Thorell's name, it can hardly be accepted without violating the law of priority in nomenclature.

Hansen and Sörensen make it clear that the Microthelyphonida are far removed from all the other orders of Arachnida, excepting the Pedipalpi. On this subject I cannot do better than to quote *in extenso* the opinion of these competent arachnologists[2]:

"While it is easy enough to show differences between Palpigradi and Scorpiones, Chelonethi, Solifugæ, Opiliones, Araneæ, and Acari, we confess that we should find great difficulty in detecting resemblances to these orders, except in the fact that they are all arachnids. Though, indeed, the order Pedipalpi is poor in species, its two suborders, Amblypygi (with the family Phrynoidæ) and Uropygi (with its tribes Oxopoei, the family Thelyphonoidæ, and Tartarides), exhibit great mutual differences, for instance, in the structure of the mouth. And, indeed, it is the most central of the orders of Arachnida; through Amblypygi it reveals decided affinity with Araneæ; through Tartarides with Palpigradi; and through Oxopoei, to a minor degree, with Scorpiones and Chelonethi. As stated by Thorell several years ago, Opiliones and Acari are closely related to each other, but we confess that these two, as well as the Solifugæ, must still be said to stand far apart from the others.

"As far as we can see, the most essential external characters of the different orders of Arachnida must be taken from the structure of (1) the mouth, (2) the antennæ (first pair of limbs), (3) the other limbs, and (4) the (real) number of the abdominal segments.

[1] Pedipalpi e Scorpioni dell' Arcipelago Malese, *Ann. d. Mus. Civ. d. Stor. Nat. di Genova*, vol. vi, pp. 327–428, 358, 2d Ser. Genova, 1888.

[2] *Loc. cit.*, pp. 236–338.

"1. The mouth of the Palpigradi (as we have already pointed out above) differs from that of all other Arachnida, nay, from that of almost all other Condylopods, in being formed exclusively by the labrum and the hypostoma. And even if Kœnenia did not offer other characteristics, this circumstance would, to our eyes, be sufficient to set it aside as an independent order.

"2. The antennæ (cheliceræ) of the Palpigradi are three-jointed, and the two distal joints form a pair of pinchers with horizontal movement of the third joint against the prolongation of the second. In this structural feature Kœnenia agrees with the Opiliones and Scorpiones, and differs most decisively from the Pedipalpi, in which the antennæ are two-jointed and do not form real pinchers.

"3. The five remaining pairs of limbs are similar in all the most essential features, as none of the anterior three pairs (second, third, and fourth) are provided with maxillary lobes which help to form the mouth, but are developed exclusively as organs of movement, like the two posterior pairs of limbs which in all arachnids, where they are found at all, are merely instruments of movement. Therefore the foot (tarsus *s. lat.*) in all five pairs is divided into a metatarsus and a tarsus (*s. str.*). In the four posterior pairs of limbs patella and tibia are well developed, while in the second pair only one single joint is present.

"4. The abdomen consists of eleven segments, which are not divided into dorsal and ventral plates. In the Pedipalpi it consists of twelve segments, which (except the three hindmost ones in the Uropygi) are divided into a dorsal and a ventral plate. (Only in Amblypygi and Tartarides the first ventral plate is very sparingly chitinized.)"

The relationship of Kœnenia to other arachnids through the central group of the Pedipalpi is comparable to the relationship of the Thysanura (Campodea, Iapyx, Lepisma, *e.g.*) to other insect orders through the Orthoptera (including Dermaptera). In fact, Kœnenia, with its simple and generalized organization, reminds one of such phylogenetically important types as Polygordius, Campodea, Scolopendrella, Amphioxus, and Myxine. Like these animals, it undoubtedly combines in its organization

many simple ancestral characters with others, which, like the reduction or absence of eyes, tracheæ, etc., may be interpreted as the effects of degeneration. Till the internal structure of Kœnenia has been studied and compared with that of other arachnids, it is hardly possible to make more precise statements than the above concerning its phylogenetic relationships.

The statements made by Grassi and Hansen and Sörensen concerning the conditions under which Kœnenia lives in Sicily and southern Italy may be repeated almost verbatim for the Texan specimens. I have found them most abundant along the margin of a cedar thicket on a rocky hill (altitude about 700–800 feet), only a few minutes' walk from the campus of the University of Texas. They occur under stones rather deeply imbedded in the ground but easily overturned. The earth under these stones is of a very definite degree of moisture, which one soon learns to recognize when searching for specimens. The animals are found crawling over the surface of the stone, very rarely on the impressed soil. Sometimes four or five will be found on a single stone. They are very agile and easily escape into some crevice or under the particles of earth adhering to the stone. They are most easily captured, as Hansen and Sörensen have shown, by means of a fine brush dipped in alcohol.

In Europe Kœnenia was found associated with Iapyx, Campodea, Pauropus, and Scolopendrella. In Texas it is associated with the very same series of forms, excepting Pauropus, which I have not yet seen in this locality. I am inclined to believe that the arachnid feeds on the eggs of Campodea or Iapyx. I infer this from the fact that the intestine and its short diverticula are always filled with something very much like the yolk-bodies of an arthropod egg. Moreover, the Kœnenia was most abundant where the very young Campodea and Iapyx lived in greatest numbers.

The association of a group of forms like Kœnenia, Iapyx, Campodea, and Scolopendrella — all very small, primitive, and synthetic types, and all devoid of pigment and visual organs — in two localities so widely separated as Sicily and Texas, is of

considerable interest from the standpoint of ecology and geographical distribution. Although there is an unmistakable general similarity, due to similarity in climate and soil, between the southern European and the Texan faunas, this does not extend to identity of species in any case of which I am cognizant, except that of Kœnenia. One is at first tempted to suppose either that the arachnid is a native of Texas (and possibly also of Mexico and the West Indies) and has been introduced into Sicily and southern Italy with the century plant (*Agave*) and the prickly pear (*Opuntia*), or that, conversely, the arachnid has been introduced into America from Europe.[1] It would seem, however, that we cannot accept either of these alternatives, but are forced to the conclusion that Kœnenia is indigenous to both continents on account of the associated forms, for we can hardly assume that the species of Iapyx, Campodea, and Scolopendrella have also been imported.[2] It is certainly more reasonable to suppose that all these forms have a wide and disconnected geographical distribution as relicts of a very ancient fauna which have survived, like many cave forms (*e.g.*, the singular blind Menobranch Amphibians, Proteus and Typhlomolge), because they have inhabited conditions subject to little or no change during enormous periods of time. A striking instance analogous to that of Kœnenia has recently been brought to light in the form of a very primitive Thysanuran, *Projapyx stylifer.* This species, an Iapyx-like insect, with

[1] These plants, introduced since the discovery of America, are now so widely distributed in southern Italy that they form an essential part of the landscape. In Munich, several years ago, I saw a fine panorama representing imperial Rome in the days of Constantine. In this painting the artist, who had evidently studied the modern Italian landscape, had been misled into the amusing anachronism of filling out a corner of his canvas with clumps of Agaves and Opuntias! The above-suggested introduction of Kœnenia into Europe gains slightly in probability from the fact that a species of Schizonotus, a genus of minute Tartarids inhabiting Ceylon and Venezuela and somewhat resembling Kœnenia in structure and habits, has been introduced into Europe in connection with exotic plants (*teste* Pocock. The Geographical Distribution of the Arachnida of the Orders Pedipalpi and Solifugæ, *Natural Science*, vol. xiv, No. 85, March, 1899, pp. 213–231, 217).

[2] The American species of these Symphyla and Thysanura are certainly very similar to the corresponding European forms, and may yet be proved to be identical in the light of study as thorough as that which has been devoted to the taxonomy of some other groups of insects.

eleven-jointed cerci in the place of the more specialized anal forceps, was discovered by O. F. Cook in Liberia. Very recently the same form was taken at Federacíon in the Argentine Republic by Silvestri.[1]

COLEBROOK, CONN., August 14, 1900.

[1] Anche *Projapyx stylifer*, O. F. Cook, nella R. Argentina. Nuovo genere di Polyxenidæ, *Zool. Anzeiger*, Bd. xxiii, Nr. 609, March 5, 1900, pp. 113, 114.

A NEW MYRMECOPHILE FROM THE MUSHROOM GARDENS OF THE TEXAN LEAF-CUTTING ANT.[1]

WILLIAM MORTON WHEELER.

ON the 10th of April last, with the assistance of Messrs. A. L. Melander and C. T. Brues, I excavated a large nest of leaf-cutting ants (*Atta fervens* Say), situated in a piece of woodland a quarter of a mile from the University of Texas. The large burrows, nearly an inch in diameter, were found to extend down to a depth of from three to five feet and to open into large chambers, some of which were fully ten inches across and five to eight inches high. A few of these chambers were traversed by the roots of a large cedar, in the shade of which the ants had dug their formicary. Descending into the pit we had dug, and braving the attacks of tens of thousands of infuriated ants, we soon discovered the objects of our search — the mushroom gardens heaped up on the floor, or, more rarely, enveloping, as aërial or "hanging" gardens, the roots that extended across the chambers.

The gardens were hastily extracted — I say hastily because putting one's hand into one of these chambers is like grasping the handles of an electric machine, so valiantly do the ants defend their property. The material, reeking with an odor like that of stale honey, was placed in large glass jars. These had to serve as artificial nests, as nests of the Lubbock and Janet pattern were obviously not suited to these aberrant ants. By the following day the ants had completely rebuilt their gardens on the bottoms of the jars.

These gardens proved to be very similar to those so carefully described and figured by Möller[2] for several South American species of Atta (*A. discigera* Mayr., *A. hystrix* Latr., *A. coronata*

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 9.

[2] *Die Pilzgärten einiger südamerikanischer Ameisen.* Jena, Gustav Fischer, 1893.

Fabr., and *A. Mölleri* Forel). Möller has described how the ants cut and bring the large pieces of leaves into their cellars, then cut them into smaller fragments, and finally com-

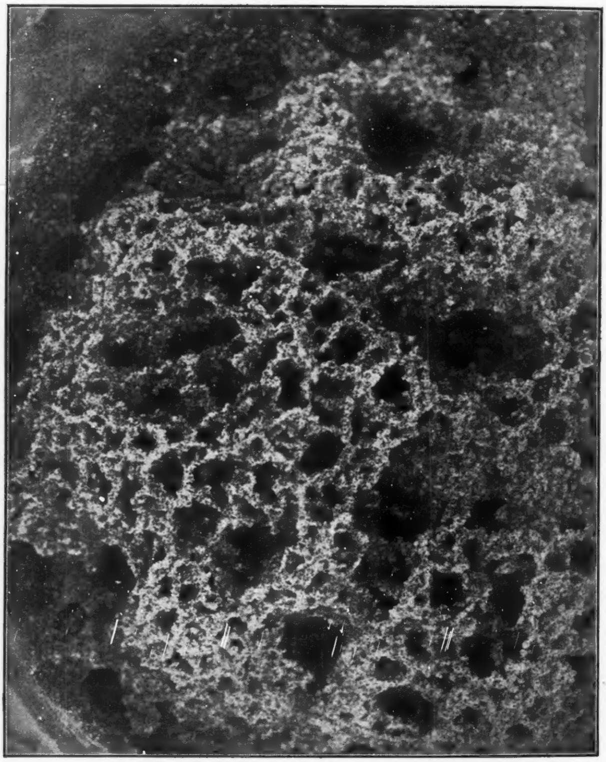


FIG. 1. — Mushroom garden of *Atta fervens* Say.

minute these still further till they form a flocculent greenish-brown pulp.[1] This pulp is heaped up and soon becomes invaded

[1] *Atta fervens*, like other species of the genus, is not fastidious in its choice of the material to be used as a soil for its gardens. Almost any vegetable substance will answer this purpose. In October, 1899, I saw a colony busily engaged collecting caterpillar excrement which had dropped from the overhanging foliage of a large sycamore. Several months later I found a large colony near the same spot marching in long procession, conveying big grains of cracked corn which

by the mycelium of a fungus (*Rozites gongylophora*). The mycelium is kept aseptically clean — *i.e.*, free from all other species of fungi and even from bacteria — and induced to grow in an abnormal way by bringing forth minute swellings which

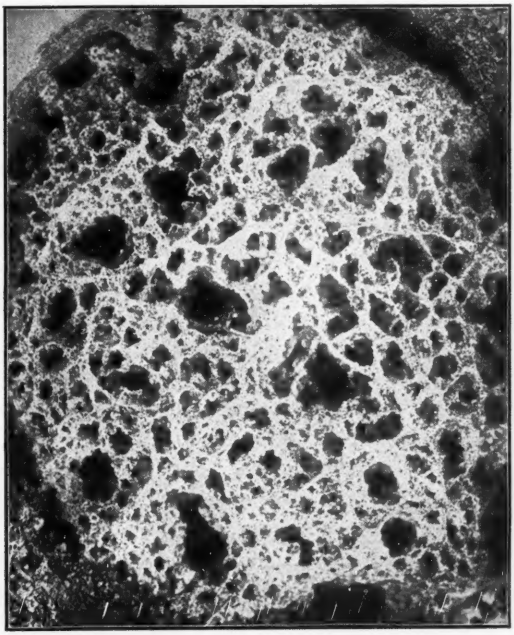


Fig. 2. — Mushroom garden of *Atta fervens* Say.

constitute the only food of the ant colony. Möller likens these swellings to the "Kohlrabi" of the German kitchen gardens.

they had filched from a mill near their nest. Sometimes they prefer to collect seeds or young flower-buds. In winter, when the leaves have fallen from all the trees except the live oaks and cedars — trees which the Attas avoid, probably because the leaves offer too much resistance to their mandibles — they garner the young leaves of the sorrel and lupine. At such times, especially when the landscape is flooded with the brilliant Texan sunshine, one may, perhaps, not inappropriately compare the ant procession with a procession of "Sunday-school children carrying banners" (McCook, On the Architecture and Habits of the Cutting Ant of Texas (Atta fervens), *Proc. Acad. Nat. Sci. Phil.*, pp. 33–40, 1879).

More recently Forel has studied the habits of two other species (*Atta cephalotes* L. and *A. sexdens* L.) in Colombia.[1] He seems to have given some attention to the rôle performed by the different casts of worker ants — casts which are also represented in our *Atta fervens* — in this process of collecting and comminuting the leaves and in cultivating the mushroom. At p. 31 he says: "The largest workers (soldiers) triturate the leaves and defend the nest. They draw blood when they bite. The indigenes are said to use these insects for closing wounds. They induce them to bite the two lips of the wound and thereupon sever the bodies from the heads, which then serve as a suture. The medium-sized workers cut the leaves from the trees, while in the nest the workers of the minim cast are forever clipping the threads of the mycelium of the Rhozites, which then develops the 'Kohlrabi,' on which the ants feed."

The shape of a mushroom garden is that of a discoidal sponge. On its upper surface the ants pile up the flocculent vegetable débris, threaded in all directions with fungus hyphæ, in the form of thin, vertical, anastomosing plates, so that as much surface as possible is exposed to the atmosphere of the chamber. This atmosphere must contain a great amount of carbon dioxide and a very small amount of oxygen. The peculiar appearance of the surface of two large gardens is shown in the photographs (Figs. 1 and 2, about ¼ the natural size). Although these gardens of *Atta fervens* closely resemble those of the South and Central American species observed by Möller and Forel, I have seen fit to figure them, both because Möller's work is out of print and may not be readily accessible to the reader, and because, to my knowledge, the gardens of our Texan leaf-cutter have not been figured heretofore. The ants leave several tubular or funnel-shaped openings (clearly shown in the figures), varying in diameter, and extending down into some chambers excavated in the base of the vegetable mass. In these chambers lives the huge queen of the colony, — an insect nearly an inch long, — the newly fledged males and virgin queens, together with the larvæ, pupæ, and attendant ants.

[1] *Biologia Centrali-Americana Hymenoptera.* Formicidæ (1899–1900), pp. 31 *et seq.*

The whole mushroom garden swarms with workers, representing all the different casts so characteristic of the genus Atta. The big-headed soldiers — like "Brownie" police officers — stalk about slowly over the surface of the comb, descending from time to time into the interior, as if to make sure that the great family is properly attending to its multifarious occupations, while thousands of minims keep moving about through the meshes of the mycelium, weeding the garden. In the presence of these varied activities and instincts one has a feeling of regret that all "anthropomorphism" is now to be banished from the study of ant life, and that we are asked to look at all this elaborate division of labor as nothing but an agglomeration of machine-like "reflexes."[1]

It is natural to suppose with Wasmann[2] that the vast amount of comminuted and decomposing vegetable matter collected by the leaf-cutting ants as a soil, or culture medium for the growth of their mushroom diet, would form a most favorable resort for a great number of myrmecophiles. Nevertheless, comparatively few of these symbiotic animals have been taken up to the present time. Besides the amphisbænians, which, though often found in the nests of the tropical Attas,[3] may not even be myrmecophagous, I find mention of comparatively few species in the literature. These include the following histerid beetles taken in the nests of *Atta fervens* in Mexico and enumerated in Wasmann's very useful *Verzeichnis*[4]: *Philister rufulus* Lewis, *Hister* (?) *costatus* Mars, *Reninus Salvini* Lewis, and *Carcinops* (?) *multistriata* Lewis. Belt[5] saw a species of "Staphylinus" in the Atta nests of Nicaragua, and Wasmann[6]

[1] See Bethe, Dürfen wir den Ameisen und Bienen psychische Qualitäten zuschreiben, *Arch. f. d. gesam. Physiologie*, Bd. lxx (1898), pp. 15–100, Taf. I u. II, 5 text-figs.; and Bethe, Noch einmal über die psychischen Qualitäten der Ameisen, *ibid.*, Bd. lxxix (1900), pp. 39–52.

[2] Die Ameisen- und Termitengäste von Brasilien, *Verhandl. d. k. k. zool. bot. Gesell.*, pp. 2–46, Wien, Jahrg. 1895.

[3] See Bates, *The Naturalist on the River Amazons*, London, 1876, pp. 51 and 52; Brent, Notes on the Œcodomas, or Leaf-Cutting Ants of Trinidad, *Amer. Nat.*, vol. xx (1886), pp. 123–131, No. 2; and Wasmann, *loc. cit.*, p. 9.

[4] *Kritisches Verzeichnis der myrmekophilen und termitophilen Arthropoden.* Berlin, Felix Dames, 1894.

[5] *A Naturalist in Nicaragua*, p. 84.

[6] Die Ameisen- und Termitengäste von Brasilien, *loc. cit.*

mentions two species of Aleochara and an Atheta found in the entrances to the nests of *Atta sexdens* L. at San Paolo, Brazil.

This short list of myrmecophiles led us to sift with considerable care the gardens of the nest we excavated. The result was a single species of myrmecophile, but this appeared in considerable numbers — more than seventy specimens being taken from three of the large gardens — and proves to be a cockroach (Blattid) of very small size and peculiar structure. With the exception of four males and two females, all the specimens are immature. The species appears to be undescribed, and as it does not belong to any genus of which I can find an account, I propose to describe it as the type of a new genus under the name of *Attaphila fungicola.*

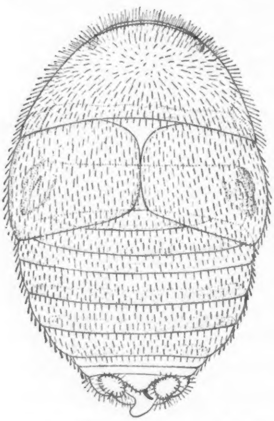


FIG. 3. — *Attaphila fungicola* n. sp., male, dorsal aspect.

In the artificial nests above mentioned the little cockroaches were frequently seen moving in and out of the tubular perforations in the vegetable mass. Occasionally one of them would mount a huge soldier that was slowly patrolling the surface of the garden, and ride about on its back or enormous head for minutes at a time. The ant did not appear to be in the least annoyed by this performance, nor did any of the other ants pay the slightest attention to the cockroaches when they were encountered in the passages. It is probable that Attaphila, like the ants, feeds on the modified hyphæ of the fungus. This is indicated by the fact that the intestines of several dissected specimens contained a whitish substance which may be the remains of the masticated mycelium. If this supposition proves to be correct, the relationship between the ants and the cockroaches is of a peculiar character. It is, in fact, a kind of myrmecoclepsy, or thieving. As the cockroaches eat the fungus cultivated by the ants for their own consumption, this kind of myrmecoclepsy may be said to differ from the typical form

exhibited by the Thysanuran Lepismina and the mite Antennophorus. In these cases, as Janet has shown in an excellent paper,[1] the guest steals some of the liquid food while it is passing from the mouth of one ant (*Lasius umbratus mixtus* Nyl.) to that of another.

Before passing to a more detailed description of Attaphila, attention may be called to a few of its structural and taxonomic peculiarities:

1. Up to the present time a genus of diminutive crickets (Myrmecophila) has comprised the only known myrmecophiles

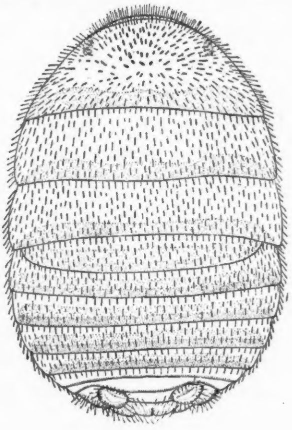


FIG. 4.

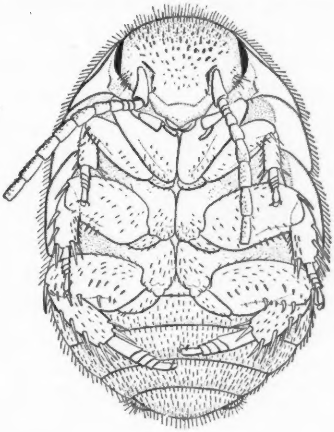


FIG. 5.

FIG. 4. — *Attaphila fungicola* n. sp., female, dorsal aspect.
FIG. 5. — *Attaphila fungicola* n. sp., female, ventral aspect.

in the great Orthopteran order.[2] With Attaphila a genus belonging to a very different family, the Blattidæ, must be added to the long list of insect myrmecophiles. Considering that there is no family of Orthoptera apparently so well fitted to enter into symbiotic relations with ants, it is rather surprising to find that other myrmecophilous Blattidæ have not been discovered, especially in the tropics, where the family is rich in species.

[1] *Études sur les fourmis, les guêpes, et les abeilles.* Note 13, Sur le Lasius mixtus, l'antennophorus Uhlmanni, etc., pp. 1–58, 16 figs. Limoges, 1897.

[2] For an account of the habits of one of the species (*M. nebrascensis* Bruner) the reader may be referred to an article in *Psyche* (1900).

2. While the Orthoptera, as a rule, are large or medium-sized insects, both Myrmecophila and Attaphila are so far below even the average stature of insects of this order that we must conclude either that they have become reduced in size secondarily in adaptation to their present habitat and companionship, or that they were originally diminutive species, and, for that very reason, better able to enter into symbiotic relationship with the ants. The latter alternative seems to be the more probable.

3. The eyes of Attaphila are vestigial in both sexes. This is indicated by their very small size, the greatly reduced number of their facets, and their irregular orbits (Fig. 6). There are scarcely more than seventy ommatidia in either eye, whereas, according to Miall and Denny,[1] there are about eighteen hundred in the eye of the common cockroach (*Periplaneta orientalis*), and some other species have even larger eyes, and therefore, in all probability, a still greater number of ommatidia. The vestigial condition of the eyes in Attaphila is of interest because it shows that the insect has become thoroughly adapted to living in the dark. It is, in fact, a truly cavernicolous form, living in caves constructed by its emmet hosts. The reduction of the eyes has not, however, proceeded so far as in another diminutive cockroach, *Nycticola Simoni*, which is known to inhabit caves in the Philippine Islands.

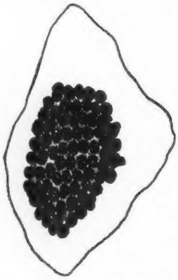


FIG. 6.—*Attaphila fungicola* n. sp., eye of adult male.

4. Additional evidence of the lifelong confinement of Attaphila to the chambers of the ants' nest is seen in the extremely rudimental condition of the tegmina and wings in the adult male, and the complete absence of these structures in the adult female. There can be no doubt that the specimens figured (Figs. 3–5) were mature, as the testes of the male contained ripe spermatozoa, and the ovaries of the female contained large, elliptical white eggs. The oötheca of this form must be an

[1] *Studies in Comparative Anatomy.* III. The Structure and Life History of the Cockroach, p. 99. London, 1886.

interesting object, if the species actually produces one. My specimens were taken too early in the year, as shown by the great number of immature individuals, so that I am unable to make any statements concerning the breeding habits.

5. It is a singular fact that in every one of my specimens of Attaphila the antennæ are incomplete, so that I cannot ascertain the full number of joints. There seems to be only one explanation of this, *viz.*, that the antennæ have been clipped off by the ants, either by the minims, which are continually trimming the fungus hyphæ, or by the large workers, which cut up the pieces of leaves brought in by the medium-sized workers. It is easy to understand how an insect like a cockroach, living in the midst of thousands of ants which are continually opening and closing their scissor-like mandibles, should be certain sooner or later to have its long antennæ cropped. One wonders how the tarsi of the cockroach escape the same treatment. The human habit of cropping the tails of horses and the ears and tails of dogs may be said to be remotely paralleled by the leaf-cutting ants when they inadvertently clip the antennæ of their household insects. The treatment to which the cockroaches are subjected in the nests of *Atta fervens* — a treatment which they have probably undergone for ages — suggests an interesting problem for those who may still believe in the inheritance of mutilations.

The number of antennal joints that escape the scissors of the ants varies in forty-five specimens, in which they were counted on both sides, from three to eleven. In seventeen of these specimens the number of joints is the same in both antennæ, the variations being: 7–7, 8–8, 9–9, and 10–10. In twenty-one cases the two antennæ differ by only a single joint, the variations being: 7–8, 8–9, 9–10, 10–11. In seven specimens the discrepancy between the two antennæ is greater, being 3–9, 5–7, 5–9, 7–9. Thus in thirty-eight out of forty-five specimens the cropped antennæ are very nearly or quite symmetrical. I am unable to explain this singular condition, which can hardly be a mere coincidence. It is probable that in this symmetrical and cropped form the antennæ of the Attaphila are more like those of the ant, and as they are kept

in constant vibration, they may on that account more readily simulate the "antennal language" of the host insects. This, however, would be the result, not the cause, of the symmetrical clipping.

6. Judging from the stumps which remain, the antennæ of Attaphila differ considerably in structure from those of other Blattidæ known to me. The joints are relatively much larger and longer, and therefore of a more generalized or embryonic type than those seen in the nymphs and adults of other species. Can this somewhat hypertrophied condition be the result of the continual clipping to which these organs are subjected?

7. The structure of its antennæ suggests that a more extended comparison of Attaphila with other Blattidæ may assign it a peculiar, if not unique, taxonomic position. On this matter my limited acquaintance with the insects of this family hardly qualifies me to write.

The following is a more detailed description of the myrmecophile that is the subject of the foregoing general remarks.

ATTAPHILA FUNGICOLA, NOV. GEN. ET NOV. SP.

Male (Fig. 3). — Length, 3–3.5 mm. Color: amber yellow; antennæ, tibiæ, tarsi, pleuræ, tegmina, and overlapping portions of terga and sterna of the thoracic and abdominal segments more brownish. Body about twice as long as broad, glabrous, covered with rather evenly distributed short, yellowish hairs. Head scarcely projecting beyond the anterior margin of the pronotum, so that only its posterior edge is visible when the insect is seen from above. Epicranium and front broad, smooth, without any traces of the λ-shaped suture and fenestræ. Labrum not bilobed, but obtusely pointed, extending a little beyond the acute, tridentate mandibles. Labial palpi scarcely half as robust as the maxillary palpi. Eyes very small, with irregular orbits, occupying the extreme lateral portions of the head and separated by a considerable distance from the antennal foveæ. Antennæ incomplete in all the specimens, both nymphs and adults; first joint rather stout, somewhat longer than the second to fifth joints taken

together ; joints six to eleven of gradually increasing length, but little narrower than the basal joint. Pronotum evenly rounded in front, considerably broader than the meso- and metanota, and as long as both of these regions taken together. There is a brown spot on either side above the eye. Tegmina rhomboidal, without traces of nervures, covering and extending somewhat beyond the meso- and metathoracic segments, and meeting for a short distance in the mid-dorsal line. Wings very small, vestigial, completely covered by the tegmina and exhibiting only very feeble traces of nervures. Abdominal segments short and broad, the first concealed, considerably narrower than the succeeding segments ; terga of seventh and eighth without hairs and lighter in color than the preceding segments ; tergum of ninth segment, forming the lamina supra-analis, subtriangular, not more than one and one-half times as broad as long, rounded behind, and fringed with a few hairs. Cerci very short, not longer than broad, ovoidal, one-jointed, covered with radiating hairs except over an elongate, glabrous area on the upper surface. Subgenital plate small, rounded and smooth, projecting beyond the supra-anal lamina and turned to the left. Above the subgenital plate lies a pointed, spine-like projection (penis ?), which turns to the right side. Stylets apparently absent. Legs short, flattened, the pairs increasing in length from before backwards ; tips of the fore femora far from reaching the pleural edges of the prothorax, those of the hind pair just reaching the lateral edges of the abdomen. All the femora furnished with spines on their lower surfaces. Tibiæ, especially the middle and hind pairs, with robust spines on their extensor edges and at their tips. Tarsi short, flattened, second to fourth joints oblique ; fifth joint provided with a distinct arolium between the claws.

Female (Figs. 4 and 5). — Length 3.25–3.5 mm. Differs from the male in the following characters : Body much broader and more rounded behind ; meso- and metathoracic segments without tegmina or wings, but with broad pleural flaps, so that these segments are slightly wider than the prothorax, though their antero-posterior diameter is only about half that of the large pronotum. Posterior edges of the lamina supra-analis

notched in the middle. Cerci with a very clearly circumscribed, linear white spot on the dorsal surface. Subgenital plate large, nearly as long as broad, evenly rounded behind.

Nymph. — Length, 1.5–3 mm. Resembling the female, except in the smaller size and the distinctly lighter color.

COLEBROOK, CONN., August 20, 1900.

ON THE VARIATION OF THE SHELL OF PECTEN IRRADIANS LAMARCK FROM LONG ISLAND.

C. B. DAVENPORT.

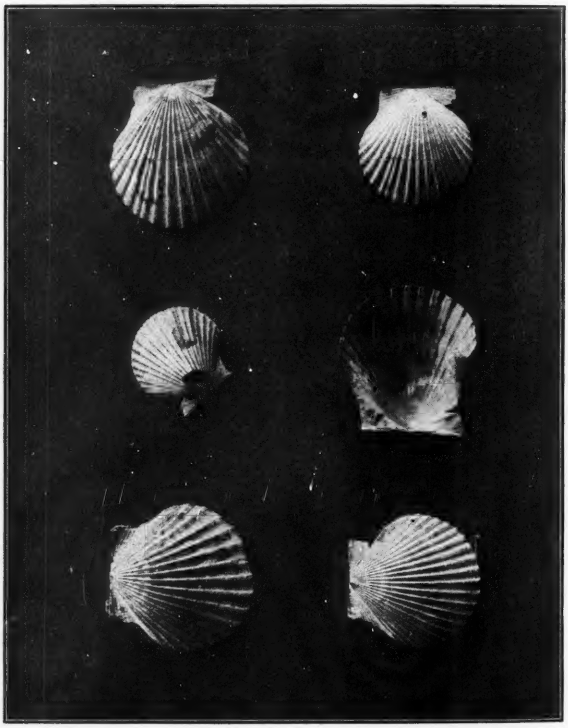
THIS study is concerned with the shells of the prevalent species of scallop, *Pecten irradians*,[1] from Cold Spring Harbor, Cutchogue, Fire Island Beach, and Oak Island Beach, Long Island, state of New York, collected during August and September, 1899.

Pecten (Fig. 1) is a genus of bivalve Mollusca whose nearly circular valves are provided with a number of ridges radiating from the beak at the hinge. The hinge is elongated tangentially, forming a pair of "ears" where the ends of the tangent depart most widely from the circle. The ears of the two valves are very different, as, indeed, are the conditions to which the two valves are subjected in nature. For when Pecten is about three millimeters in diameter it attaches itself, so that it lies in a horizontal fashion, by means of a byssus. It remains attached until it is from ten to thirty millimeters long, after which it lives free. The byssus passes to the exterior between the anterior ear of the right valve and the main body of the shell; consequently, when the right valve is viewed exteriorly, the right-hand ear is deeply notched,[2] while the left-hand ear is not notched at all. In the left valve both

[1] As it is necessary nowadays to recognize that a specific name by itself means very little, a string of synonymy must be appended. Recent names for the "species" or "variety" to which the form-units that I studied belong, are: *Pecten* (*Plagioctenium*) *gibbus*, var. *irradians* (Dall, **'98**, p. 748), and *Chlamys* (*Æquipecten*) *irradians* (Verrill, **'99**, p. 77). Dall recognizes two northern varieties of gibbus: "gibbus var. borealis" of the New England coast, and "gibbus var. irradians" "from New Jersey" south. Neither of his descriptions of these two forms agrees closely with the Cold Spring Harbor form-unit, which might therefore receive a new varietal name were not the futility of this endless naming, alas, too evident.

[2] Fig. 1, top.

ears are unnotched.[1] Since the byssus passes out on the right side, the right side of the young Pecten lies next the substratum, while the left side is broadly exposed to the water above. I was interested to see whether the Pecten ever lies on its left side — a condition which would be comparable in a way



a b

c d

e f

FIG. 1. — Photographs of *Pecten irradians* from Cold Spring Harbor: *a*, *b*, two cases of partial division of a rib; *c*, case of interpolation of a secondary ridge between two primary ones; *e*, *f*, showing an extremely small (14) and extremely large (20) number of rays.

with left-handedness in dextral gastropods. If the abnormal condition ever occurs, it will show itself by the circumstance that the notch will appear on the left side of the valve, viewed exteriorly. Now, although over a thousand notched shells

[1] Fig. 1, bottom, left.

were examined by me, I found no exception to the condition of being notched on the right ear. Jackson ('90) found no exception to the normal condition, and states that Professor Hyatt examined over three hundred specimens of *P. irradians*, all of which lay on the right side. There is, accordingly, a wonderful constancy in the tendency to lie on the right side; and this tendency is characteristic of many related genera, such as Pinna, Spondylus, Plicatula, Hinnites, and Anomia. The constancy in the position of the notch is referable to a constancy in the position of the byssus gland. This is normally laid down in development as a pair of glands, right and left. Apparently only the right gland persists, or else perhaps both glands are united on the right side. Whatever the morphogenetic process which determines the position of the byssus gland, it is a remarkably constant one.

The shell of *P. irradians* exhibits on its outer surface five areas: First, a middle one, characterized by large prominent ridges, alternating with furrows. Since these are made by foldings of the mantle, the outer ridges appear as grooves on the inner surface, and the outer grooves as inner ridges. Second, a pair of "ear" areas characterized by fine linear elevations which do not correspond with marked grooves on the inner face. Third, a pair of triangular areas, lying between the middle areas and the ear areas, and transitional between them. These may be called the "transition" areas. They bear indistinct radial thickenings. These areas are bounded laterally by the ear areas. On the right, or notched, side of the right valve the boundary is distinct; on the left side of the right valve and on both sides of the left valve the lateral limit of the transitional area is determined by the line where the ear begins. But this is not a very precise line. The transitional areas are bounded mesially by the middle area. The limit may be defined as the line where an internal groove corresponding to an external ridge first appears. Since the external ridges on the shell are so often obscure, I early abandoned the attempt to count them. I then noticed that the internal grooves are much more precise than external ridges;

so I counted these grooves to get the laws of variation in the number of radii in Pecten. Such a study is of some importance, because the valves on which the series occur are not typically symmetrical, but show a certain tendency towards being dorsal and ventral. We have here, then, a case among pelecypods resembling that of the flounder among fishes.

The grooves in all the shells examined ran continuously from near the beak to the free margin of the shell. I did not observe any case of bifurcation of a groove, the obliteration of a groove distally, or the introduction of a new groove towards the free margin of the shell. This is the more remarkable because in allied species, such as *P. eboreus* Conrad (see Dall, '98, p. 749), some of the ribs become obsolete toward the margin, and in others, as *P. islandicus*, new grooves are begun at various stages in development of the shell.

The number of grooves corresponds to the number of ridges in the "middle" area. But the number of grooves on the inner face of the shell is not always definite, especially towards the transition area. We here sometimes find a very slight lateral depression passing hinge-ward only one-tenth to one-fifth the whole distance. The rule was adopted to count as grooves only those depressions where the margin of the shell was folded to form a complete U rather than merely an L. A strictly ambiguous or halfway groove at both ends of the series counted for one full groove, but when only one groove was ambiguous, that was omitted from the count. About ten per cent of the shells from Cold Spring Harbor and all from the other two localities were counted by my wife, Gertrude C. Davenport; the rest were counted by myself. We satisfied ourselves of the equivalence of our estimates of doubtful cases by making a series of independent determinations on a number of identical shells, finding that we agreed in our determinations in the case of each individual shell.

The shells from Cold Spring Harbor were picked up on the sand spit, where they had been thrown by waves and shifting sands. They were therefore not pairs, and were not consciously selected. The shells from Fire and Oak Island Beaches were picked up on the beach and were also separate and

often somewhat water-worn and broken by the pounding of the surf which rolls in on that unprotected shore; but no shells were rejected unless so worn or broken as to obscure the grooves. The shells from Cutchogue were very kindly sent me by Mr. Huron Bretsch. Mr. Bretsch writes me that all came from Peconic Bay, near Cutchogue, some from a shell heap left by fishermen, and some picked up on the shore by himself. He says, "I did not pick out the best ones, but took them at random."

Results. — I give in tabular form the observed and per mille distribution of frequencies of the different classes of groove numbers for the two valves from the three localities.

Classes	Right (Lower) Valve						Left (Upper) Valve					
	C. S. H.		Cutchogue		F. I. & O. I.		C. S. H.		Cutchogue		F. I. & O. I.	
	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.
13							1	1.2				
14	2	1.9			1	20	2	2.5	5	32.7	2	95.2
15	15	14.3	33	117.4	6	120	43	53.2	38	248.4	4	190.5
16	108	103.3	95	338.1	15	300	269	333.0	77	503.2	10	476.2
17	515	492.3	127	452.0	24	480	320	396.0	27	176.5	4	190.5
18	308	294.5	22	78.3	4	80	151	186.9	4	26.1	1	47.6
19	90	86.0	4	14.2			22	27.2	2	13.1		
20	7	6.7										
21	1	1.0										
	1046	1000.0	281	1000.0	50	1000	808	1000.0	153	1000.0	21	1000.0

The quantitative study of these seriations gives the following constants calculated from the observed and not the per mille data. Here n is the number of individual shells counted; M is the *mode*, or the prevailing number of rays; A is the average number of rays; σ is the standard deviation or index of variation; c is the coefficient of variation; F is the critical function of Pearson, by which the type of the curve is determined. The numbers following the $\pm$ sign are the probable errors of the determinations. For further information concerning this analysis of frequency distributions, the reader is referred to the works of Duncker in *Roux's Archiv*, 1899, or my *Statistical Methods*, New York, 1899.

	RIGHT (LOWER) VALVE			LEFT (UPPER) VALVE		
	C. S. H.	Cutchogue	F. I. & O. I.	C. S. H.	Cutchogue	F. I. & O. I.
n	1046	281	50	808	153	21
M	17	17	17	17	16	16
A	17.353 ± .018	16.534 ± .034	16.480 ± .084	16.790 ± .022	15.954 ± .105	15.90 ± .14
σ	0.876 ± .013	0.852 ± .024	0.877 ± .060	0.916 ± .015	0.881 ± .075	0.97 ± .10
c	5.049 ± .074	5.15 ± .15	5.32 ± .36	5.457 ± .092	5.52 ± .47	6.11 ± .64
F	− 1.46			− 0.0476		
Type	IV			Type IV or Type V[1]		
Skewness	+ 0.023			+ .000000058		

[1] $F \times \mu_2^3 = .028; \frac{3\nu_2^2 - 2\nu_1^4}{\nu_4} = .9711.$

Conclusions. — From these numerical results we may draw the following conclusions:

1. The right valve has on the average about half a groove more than the upper valve (more precisely .56+ more). This result is due to the circumstance that the series of ridges and grooves must end either in a ridge or in a groove. Of course it may end in a ridge at one end of the series and a groove at the other; but in the majority of cases there is a high degree of symmetry in the ends of the series. Now I find, in looking over the right and left shells without prejudice, that in the right shells the series tends strongly to end in a groove, so that the last or most lateral ridges of the series (looking at inner surface of shell) are very distinct. In the left valve, on the other hand, there is a more marked tendency for the series to end in a ridge, so that the last grooves are distinct. For in twenty-three right valves I found only three in which the series ended in ridges, whereas twenty ended in grooves; whilst in twenty-nine left valves in fourteen cases the series ended in ridges, and in fifteen cases in grooves.[1] Since the series of the right valve show this prevailing tendency to end in grooves, the excess of grooves on the right valves is fully accounted for. Doubtless if ridges had been counted instead of grooves, the right valve would have averaged one-half a ridge less than the left.

[1] The tendency to end in a groove or a ridge is beautifully shown in *P. operculatus* Linn.

2. The prevailing number of rays in the right valves from all localities is seventeen; in the left valves from Cold Spring Harbor it is seventeen also; but at the east end and the south shore of Long Island it is sixteen. Comparison of the averages shows that the Cold Spring Harbor shells tend to have a comparatively large number of rays on both valves — in the mean 0.8 of a valve more than in the other localities. In the average number of grooves Cold Spring Harbor stands widely separated from the other two localities, which are closely related.

3. Using as an index of variability the standard deviation σ, it appears that the Cold Spring Harbor shells are possibly more variable than those from Cutchogue. However, the difference is less than the probable error, and no stress is to be laid on the fact. The same is true of the apparently greater variation of the South Shore shells. So we may conclude that, despite differences in the mean, the variability of the grooves is constant. This result accords with certain others obtained by *counting integral variates*. Duncker ('**99**, p. 328) says: "While the average values of a character may differ widely in different form-units of the same species, the indices of variability remain fairly constant, not only in the form-units of the same species, but also in those of species belonging to different genera, even to different families. This fact does not seem to me to have been sufficiently regarded hitherto; the explanation of it is, I suppose, the constancy of the physiological capacity of a given organ for reacting to the individual causes of variation . . . with respect to a given character. Some authors, however, seem to assume a more or less constant relation between the height of the average and that of the index of variability of a character." I will not here discuss, as I propose to do elsewhere, the relation between the mean and the index of variation. The matter needs special investigation.

4. The variability of the right or lower valve is in every case less than that of the left or upper valve, and this difference in the case of the Cold Spring Harbor specimens is greater than the probable error. From this fact we may conclude that the right valve is the more conservative, or responds less to

varying environmental conditions. This small variability of the lower valve is in accord with the fact that the young shell of Pecten is larger and better preserved on the right valve than on the left. Again, in *P. squamosus*,[1] in which the scales are becoming obsolete in the adult, they are found at a later stage on the right valve than on the left. In other cases,[2] the grooves of the left valve divide and become ornamented, while the right valve remains simple. Here, then, the index of variability is an index of phylogenetic changeableness.

5. The type of distribution of frequencies was determined only for the shells from Cold Spring Harbor, because they alone were sufficiently numerous for this purpose. The right valve is Type IV, with a rather small skewness however, namely, +0.023. For the left valve the distribution is remarkably near the theoretical normal distribution, the skewness being +.0000000058. The skewness will rarely be theoretically zero. Applying Pearson's limits, the distribution may be said to be of the normal type. Applying the prevailing method of interpreting these results, we may say that the Cold Spring Harbor race is, as regards the grooves in the upper valve, very stable; while as regards the grooves in the lower valve it exhibits a slight tendency to the excessive production of a large number of rays, or to the selective annihilation of the small numbers. The excessive production of large numbers may be due to innate or to external causes.

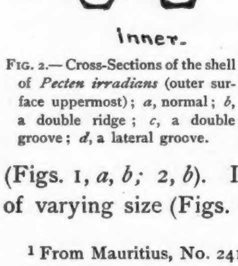


FIG. 2.— Cross-Sections of the shell of *Pecten irradians* (outer surface uppermost); *a*, normal; *b*, a double ridge; *c*, a double groove; *d*, a lateral groove.

Abnormalities of the grooves often occur. All gradations were found between the condition of a broad ridge on the inner face of the shell and the condition of a double ridge, the halves of which were separated by a groove (Figs. 1, *a*, *b*; 2, *b*). In other cases the groove contains a ridge of varying size (Figs. 1, *c*; 2, *c*). Occasionally a small groove

[1] From Mauritius, No. 2412, Field Columbian Museum.

[2] For instance, *Pecten madreporium*, from Singapore, No. 6109, Field Columbian Museum.

lies close by the side of one of normal size (Fig. 2, *d*). All these abnormalities may be regarded as congenital. In addition I have found certain variations, probably due to injury of the mantle. Jackson ('90) remarks that the mantle is subject to injury by fish and thereafter regenerates only imperfectly. He accounts for the incurved edge of the shell which is occasionally found (Fig. 1, *d*) as follows: "When one mantle border is injured, the other repairs the damage which would be caused by local want of shell growth, by curving the shell deposition of the injured side rapidly inwards, thus obviating the deficiency of the injured area. This ingrowth is probably induced by the lack of resisting support on the part of the damaged border."

We have now to consider the question whether the individual variations and the abnormalities which we have studied throw any light on the question of the origin of species in the Pectinidæ. This involves an examination of the genus Pecten.[1]

This genus has been variously subdivided. The subgenus Chlamys (as defined by Dall, '90, p. 695), which includes *P. irradians*, is a fairly well defined subdivision, and our attention may be confined to it. The species all have "ribs," as I shall designate the alternating ridges and furrows, which are true flutings or corrugations affecting both inner and outer surfaces of the shell. If the ribs are absent in any case, they have secondarily become lost. The valves are nearly equally inflated; the ears vary from a nearly equal condition to one of great inequality. The anterior ear of the right valve is typically notched, to let pass the byssus. In judging of the position of *P. irradians* we need to know something of the phylogeny of the subgenus Chlamys. We can infer something, as Jackson ('90) has, on the recapitulation hypothesis, by noting the condition of the shell at different stages of development. The record of these changes remains in the adult shell, and can be studied by examining the beak and adjacent parts. Fossil remains also tell something. The beak

[1] In making this examination I have had the great privilege of examining, with the kind assistance of Dr. S. E. Meek of the Field Columbian Museum, the very fine collection of Pectens possessed by that institution.

of the valves, especially the *right* valve, shows an area without striations ; at this stage also the hinge is as long as the greatest diameter of the shell, and there are no sharply marked off "ears." At this stage the shell resembles the Devonian Aviculoids, which are usually regarded from this as well as from paleontological evidence as the ancestors of the Pectinidæ. The genus Pecten began to emerge in the Devonian and Carboniferous. These emerging Pectens, Pterinopecten (Devonian), had a long hinge line, with large, not sharply defined, nearly equal ears, and with a byssal sinus on the right valve. Both the valves seem to have been convex. Jackson (**'90**, p. 386) says that *Pterinopecten dignatus* Hall and other species bear a close resemblance to the young of *P. irradians*. In Aviculopecten (Devonian), which represents another step towards Pecten, we see the hinge becoming shorter and the two ears well defined ; a deep byssal sinus occurs on the right valve in many species. In both Pterinopecten and Aviculopecten the shell is corrugated. These dawning Pectens then had the characters of the subgenus Chlamys, which may consequently be regarded as the most primitive of the subgenera of Pecten. *P. irradians*, therefore, belongs to the most primitive division of the genus Pecten.

Inside the subgenus Chlamys the species show modifications in various directions. There are species in which the posterior ear has become very much smaller relatively than in irradians ; *e.g.*, islandicus of our coast, hericeus (= hastatus) of the California coast and Vancouver, and niveus of Great Britain. Associated with this diminution in the posterior ear is the formation of scales in a linear series on the ribs. The scaled condition is secondary, as is clearly shown in niveus, where the younger shell is without scales ;[1] the scales are obtained only in the later stages. The inequality of the ears is also derived, for in the primitive condition there was equality of the auricles.[2] This group is therefore more modified than *P. irradians*.

[1] The scales appear earlier on the lower than on the upper shell.

[2] It is interesting that in certain species, *e.g.*, *P. squamosus* of Mauritius, the scales seem to be secondarily disappearing. This species would seem to have originated from an ancestor resembling *P. hericeus*.

A second class of modifications consists in the formation of striations on the ribs. These striations are thickenings of the shell in radial lines. They may in some cases become so pronounced as to form ribs at the periphery of the shell. These striations I regard as secondary, both because they are clearly something added to the simple rays which we have in Pecten, because the young stages of Pecten show no such striations, and because in the young stages of striated shells the striæ are absent. Consequently these striated species are more modified than irradians.

A third class of modifications is that of smooth or nearly smooth shells. Of this condition our *P. magellanicus* (= clintonius) is typical. Although the ancestors of Pecten were smooth-shelled, the magellanicus modification is by no means ancestral, for if, as Verrill ('99, p. 78) states, "when about 3–4 mm. in length it develops small, regular, raised ribs over the whole surface of the upper valve and usually at both ends of the lower one," this shell must have been derived from ribbed ancestors. So, too, in *P. glaber* of Smyrna and *P. danicus* of Scotland we have the process of obliteration of ribs going on with the formation, apparently, of a few large secondary crenations.[1] In all cases we start with a ribbed form like irradians.

Let us consider, finally, the relation of irradians to the other species of Chlamys in respect to the number of ribs. The data for such a comparison can be got from an important lot of countings made by Dall ('98) and from some determinations of my own made on shells in the collection of the Field Columbian Museum. I give only modes (or, in the absence of sufficient data, the ranges) for the *left* valve. In some cases external ridges are given because these are often alone available and Dall has counted ridges only. In other cases I give internal grooves ; these are exclusively derived from my countings. Since the extreme lateral external ridges usually have no internal grooves, the groove numbers run one or two lower than the ridge numbers.

[1] An insufficient amount of material requires me to put forward this explanation with some reserve.

		Ridges.	Grooves.
P. nodosus,	Southeastern North America . .	7–10	
P. jeffersonius,	Miocene fossils, S. E. North America .		
	var. septenarius	8	
	var. Jeffersonius	10	
	var. edgecombensis	14	
P. latiauratus,	var. monotimeris, California . .		12
P. pallium,	Pacific Islands		13
P. madisonius,	precursor of *P. jeffersonius*, fossil .	15	
P. gibbus,	var. amplicostatus	16	
	var. borealis, recent	17	
	from New England, irradians . .		16
	" South Shore, L. I., irradians .		16
	" Cold Spring Harbor, L. I., irradians		17
	var. irradians, recent	19	
	" " fossil, late Pliocene .	19–22	
	var. dislocatus, fossil, late Pliocene .	18	
	" " recent . . .	20	
P. eboreus,	precursor of *P. gibbus* (= irradians)		
	Miocene and Pliocene	22	
P. operculatus,	British		18
P. hericeus,	Vancouver		19
P. varius,	Naples		24

From this table it appears that *P. (gibbus) irradians* is intermediate in the number of its ribs between the extremes. The question arises whether in phylogeny the number of rays has been increasing or decreasing to produce *P. irradians.* From the data given and on the assumption that *P. eboreus* is the ancestor of *P. irradians* we have the series:

P. eboreus, Miocene and Pliocene	22 ribs.
P. irradians, late Pliocene	22–19 ribs.
P. irradians, recent	19 ribs.

This seems to indicate that there has been a tendency for the number of ribs slightly to decline. On the other hand, the fossil *P. gibbus,* var. dislocatus (the southern form of irradians), shows an increase from eighteen to twenty ribs in passing from the late Pliocene to the present. Also, the more specialized species, such as varius, twenty-four rays; striatus, fifty-one rays; miniaceus (South Africa), thirty to forty rays; and islandicus (east coast, United States), thirty-five to fifty rays,—

tend to larger numbers than irradians. In many of these cases of species, with a larger number of rays at the periphery, there is an ontogenetic increase. Thus the epionic shell of miniaceus has only sixteen rays, and the left valve of islandicus has only nineteen ridges at 5 mm. from the beak. These species, then, judging from ontogenetic changes, have been derived from species with fewer rays, such as we find in irradians. Finally, Dall ('98, p. 748) concludes in respect to *P. gibbus* (= irradians in part): "Taking all varieties together, the generalization may fairly be made that in the Pliocene the proportion of specimens with less than nineteen ribs is decidedly larger than among recent shells." The apparent contradiction between this statement and the figures which Dall gives for the number of rays in fossil groups suggests that the figures are based on too few individuals to be significant. It may be concluded, consequently, that the condition of about eighteen rays exhibited by *P. irradians* is not far removed from the ancestral condition, and that most of the species with numerous rays have been derived from forms which, like irradians, have fewer than twenty rays.[1]

These facts have a close relation to those of individual variation in our form-unit of *P. irradians*. First, the number of ribs, which is so variable in the individuals of the form-unit studied, is likewise very different in the different species of the genus.

Again, as we have seen, the asymmetry of groove frequencies in *P. irradians* is in the positive sense; that is, there is a tendency to an excess of rays; in other words, there is a tendency to vary in the direction of *P. islandicus;* to go the path that it has trod.

[1] I have paid some attention to the ways in which the increase in rays is brought about in the different species. In islandicus the nineteen rays at the beak increase in the left valve to forty, chiefly by the interpolation of new ridges in the old furrows. Such interpolated ridges start at various stages. In the older shells the increase is also effected by bifurcation of certain of the larger ribs, of which there are about six to eight. In the right valve, on the other hand, the ribs increase chiefly by bifurcation, although interpolations also occur. I have observed the same difference between the left and right valves in other species; namely, *P. alvolineatus* Sby., from Viti (Field Columbian Museum, No. 6111); *P. tigrinus* Müll., from Great Britain (Field Columbian Museum, No. 6118); and *P. madreporarium* Petit, from Singapore (Field Columbian Museum, No. 6109).

The abnormalities of irradians also become significant in comparison with the normal condition in other species. The grooving of an external ridge takes place normally in *P. islandicus,* right valve, as we have seen. The development of a rib by interpolation in a groove is also typical of *P. islandicus,* left valve. The formation of a small rib on the side of a typically large one is found on the left valve of *P. islandicus,* is the regular thing in *P. australis,* from South Australia,[1] and is also common in other species where the number of rays increases with age. How are we to interpret this correspondence between an abnormality and a normal condition in another species? There was a time when we should not have hesitated to put the phenomenon in the category "reversion." But we have so many instances of parallelism between the abnormal of one species and the normal of a second that we should be cautious in attributing them all to reversion. It seems better to recognize that a physiological potentiality which crops out (as an abnormality) in various species becomes fixed as a normal specific character in one of them.

SUMMARY.

The right or lower valve of *P. irradians* has on the average half a groove more than the upper, because the series of alternating ridges and grooves of the right valve has a prevailing tendency to end in grooves. Of three Long Island localities, the most nearly land-surrounded shows Pectens with the greatest number of rays. The right valve is less variable than the left, a result which agrees with the fact that the right valve of Pectens is generally more archaic than the left. The variation is nearly normal in both valves; more so in the left than in the right valve. The skewness is positive, showing a slight tendency towards an excessive production of the many-rayed individuals, or the selective annihilation of those with few rays. This positive skewness is paralleled by the fact that *P. irradians* seems to be developing towards a larger number of rays. The various abnormalities of Pecten are either explained as

[1] Field Columbian Museum, No. 8430.

self-adjustments to accidents or as sports which represent typical conditions in allied species.

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VARIATIONS IN THE CREST OF DAPHNIA HYALINA.

MINNIE MARIE ENTEMAN.

THE characteristic tendency of Daphnia to form local varieties is expressed in *D. hyalina* by a variability in the cephalic crest, such that every kind of crest displayed in the genus may be observed in the species, which at the same time remains relatively constant in other distinguishing characters of *D. hyalina*. The object of this paper is a comparison between the American and the European forms, with a more careful inquiry into the conditions for several lakes offering widely different varieties.

My thanks are due to Professor E. A. Birge, of the University of Wisconsin, who furnished me with collections from northern Michigan and Wisconsin, and through whose kindness I had access to the literature on the subject; to Professor C. B. Davenport, of the University of Chicago, for many helpful suggestions in revising the results of my study; and to my brother, Karl E. Enteman, for assistance while collecting from southeastern Wisconsin.

Historical. — *D. hyalina* was first found by Leydig in the depths of the "Schlier See," and was given its name on account of its extremely pellucid character. Following are the chief points in its description as given in Leydig's *Naturgeschichte der Daphniden*, 1860: About as large as *D. longispina*, but somewhat narrowed, and at first sight distinguished from all known species by its extreme transparency; the head prolonged into a long, straight rostrum, without a ventral concavity, and so closely approximated to the thorax that the posterior outline is hidden between the valves of the carapace; macula nigra present; terminal claw smooth, showing under high power of microscope fine cross striations at base; the fornix much higher than in all known forms, the shell delicately

sculptured into rhombs and prolonged posteriorly into a long dorsally directed spine (Fig. 1).

Observers subsequent to Leydig failed to find this species, but described forms which resembled it in all points excepting the form of the crest. The deviations here were sufficiently great to lead to their classification as distinct species. Such were *D. gracilis* Hellich, *D. pellucida* Müller, and *D. galeata* Sars; and not until recent years, when forms transitional between them and *D. hyalina* were found, have these come to be regarded as varieties of *D. hyalina*.

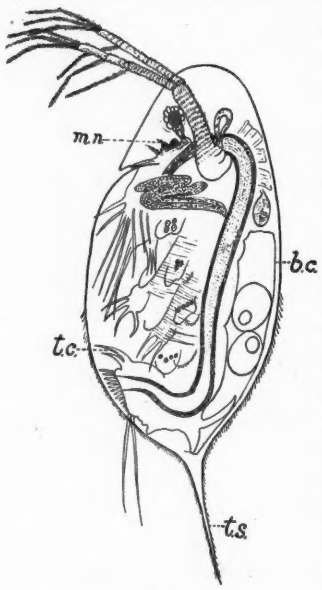

FIG. 1. — *Daphnia hyalina* Leydig; *m.n.*, macula nigra; *b.c.*, brood cavity; *t.c.*, terminal claw; *t.s.*, terminal spine.

Of *D. galeata*, Sars ('63) said: "It is distinguished from all other forms by the very characteristic development of its crest, which projects forward in an acuminate apex, giving the head a certain likeness to a helmet of the olden time. This singular projection undergoes noticeable variations in different localities. Sometimes it takes a direction straight forward, sometimes it is bent downward, and again it is very short, almost disappearing in adult females. In other localities the apex is highly developed, sabre-pointed, and in some even slightly recurved." The writer, however, fails to note a resemblance between any of these varieties and *D. hyalina*. In his résumé of the characters of *D. pellucida*, Müller ('68) makes mention of a pectinated terminal claw on the telson, which, if it is anything more than the fine striations noticed by Leydig, would serve to separate the two species; but later, in his "Cladoceres des Grand Lacs de la Suisses," he identifies Pellucida with Hyalina, since he found "all transitions between *D. hyalina*

with a low even crest and terminal claw deprived of basal denticles, and *D. pellucida* with a large crest and a terminal claw ornamented at its base by a series of slight denticles." *D. gracilis* Hellich was distinguished from the foregoing mainly by its great height of evenly rounded crest, and was believed to be closely allied to *D. galeata*. Eylmann ('86) was the first to recognize the close relationship among the forms hitherto described. He classed them all as varieties of *D. hyalina*. Matile ('90) takes the same view. I translate from Eylmann:

"In the course of my work the conviction was more and more forced upon me that all Daphniæ possess a tendency toward the formation of local varieties, and indeed these variations are not limited to one part of the body, but extend to all parts; now it is the shape of the head, now the form of the valves, and again the size and development of the appendages, which give rise to the distinction as a variety. *However, the differences which arise in one habitat are very slight*, and extend to only a few individuals; but if we compare Daphniæ from separate localities, the differences are so striking that a doubt often arises as to whether the specimens are of the same or of different species, and often the question cannot be decided until transition forms are found in other localities which make possible a gradual change from one form to another." He cites *D. hyalina* as the best example of this character, and gives as a reason for these manifold deviations from the type the fact that the species is rigidly confined to lakes, the consequent isolation offering very favorable conditions for the origination of new forms. Richard ('96), in his "Revision des Cladoceres," included the above-mentioned forms, together with *D. plitvicensis* Sostaric[1] and *D. rectifrons* Stingelin,[2] in the single species *D. hyalina*, with the remark: "*D. hyalina* est d'ailleurs très variable, comme on le verra plus loin."

The American Representatives of the Species. — These have been but little studied. A brief description of two varieties

[1] Low, rounded crest.
[2] Similar to var. *galeata*.

found in lakes Wingra and Mendota was given in "List of Crustacea Cladocera from Madison, Wis.," by Professor Birge in 1875, while Herrick ('81) has described several forms which plainly belong to this species. Later observation led to the fact that "almost every lake possesses its own variety of *D. hyalina*"; and with this in mind Professor Birge, several years ago, gave me collections from a number of our lakes, and suggested that I study the different forms, their relations to one another and to the various European types. The material was all pelagic and collected from various parts of Michigan and Wisconsin. The lakes differ widely in character, from the small, reed-bordered Lake Wingra, or shallow Winnebago with its sandbars, to lakes like Mendota, of far greater depth, and whose shores slope from precipitous bluffs.

In general, the forms are remarkable for their close resemblance to the varieties of Europe, every variety but one being represented here; while several differ widely from any thus far described for Europe, but correspond in external appearance to the American representatives of widely different European species. Thus, while some European varieties of *D. hyalina* vary in the direction of the Kahlbergiensis, our forms vary to correspond with the American species Retrocurva and Breviceps. The transitions between the different types are sufficiently gradual to connect them with the original *D. hyalina* Leydig, thus seeming to confirm what has heretofore been, in a measure, assumed by other writers, — that the form first discovered is the one from which the others have departed. Following is a diagram (Fig. 2) representing the deviations from an assumed central form found in Lake Wabasis, Michigan, while the table on page 884 gives the principal characters in which the varieties are observed to differ. Each variety is named from the lake where it occurs.

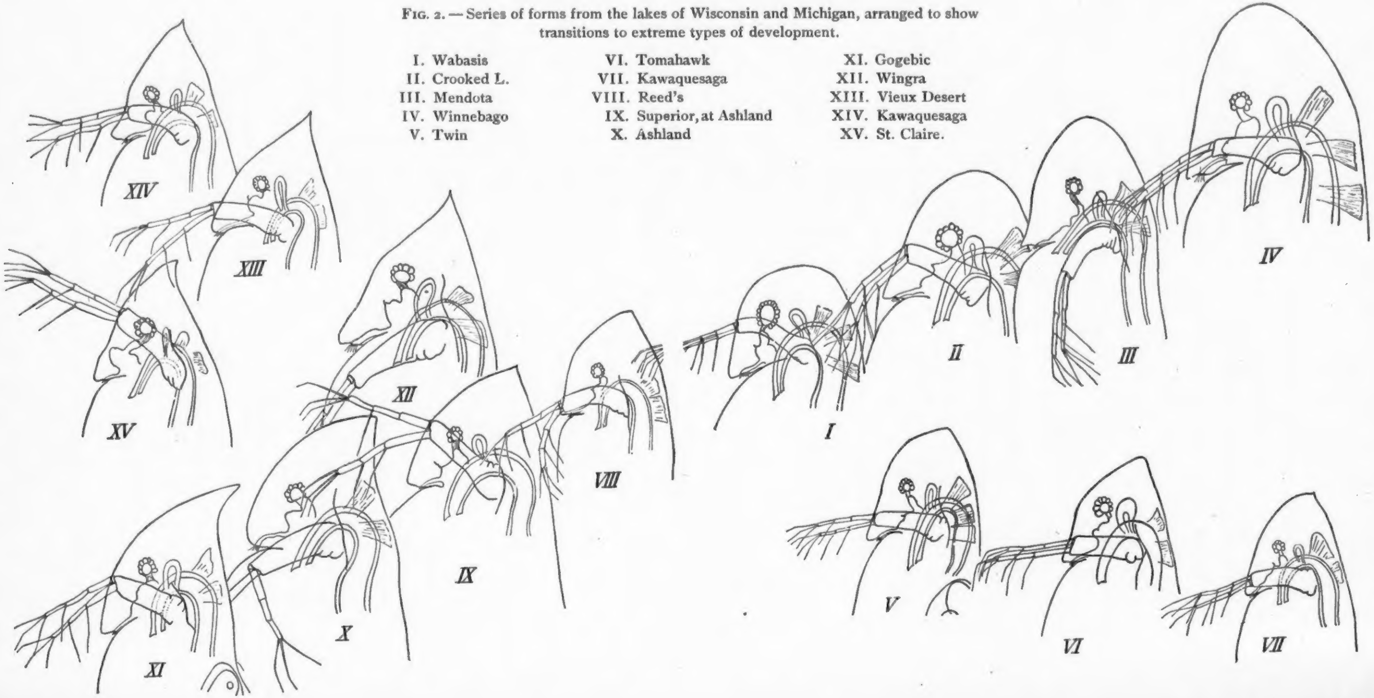

FIG. 2. — Series of forms from the lakes of Wisconsin and Michigan, arranged to show transitions to extreme types of development.

I. Wabasis	VI. Tomahawk	XI. Gogebic
II. Crooked L.	VII. Kawaquesaga	XII. Wingra
III. Mendota	VIII. Reed's	XIII. Vieux Desert
IV. Winnebago	IX. Superior, at Ashland	XIV. Kawaquesaga
V. Twin	X. Ashland	XV. St. Claire.

NAME.	CREST.	ROSTRUM.	ANTENNÆ.	SPINE.
Wabasis	Round, low, slightly narrower than carapace	Long	Basal joint curved, barely reaches margin of the head	Long, slightly upturned
Crooked	Little higher than the above-mentioned form	Long		
Mendota	Round, high, more than $\frac{1}{2}$ the length of carapace	Postero-ventral, ending in sharp point	Curved, slender, barely reaching margin	Very long, recurved postero-dorsally
Winnebago	Nearly $\frac{2}{3}$ length of carapace and as broad	Short, rounded	Slight, with short basal joint	Middle of lateral aspect, and a little longer than head
Twin	Pointed apex, dorsal to median line of lateral aspect	Rather short	Slight, with short basal joint	
Tomahawk	Apex somewhat more pointed than the foregoing	Rather short	Slight, with short basal joint	
Kawaquesaga, at Minocqua	Apex slightly acuminate	Rather short	Slight, with short basal joint	
Reed's	Antero-dorsal convexity prolonged into blunt apex	Short	Strong basal joint greatly curved	
Superior, near Ashland	Ventral line curved, dorsal straight or curved slightly upward	Extremely short and rounded	Basal joint nearly straight, and strong	
Gogebic	Elongated and strongly recurved	Long and blunt	Short and slight	
Wingra	Triangular, prominent subocular elevation	Short and blunt	Large and strong	Near median line of lateral aspect
Vieux Desert	About $\frac{1}{3}$ length of carapace, apex recurved	Long and blunt	Large and strong	
St. Claire	Dorsal and ventral curves marked, apex recurved	Rather long and rounded	Strong	
Kawaquesaga, at Minocqua	Dorsal and ventral curves marked, apex recurved	Rather long and rounded		

Types. — These numerous varieties may be classed under five types, three of which are quite the same as those described for Europe under the names Pellucida, Galeata, and Gracilis, while the other two are peculiar to our lakes. These are the St. Claire form, characterized by slight elongation and triangular shape of the head, and the Gogebic form, with greatly elongated and compressed shell, slender antennæ, and recurved apex of the crest. These two varieties differ most widely from the typical Hyalina, and at first sight appear to be entitled to specific rank. The most striking deviation is toward a form with pointed crest, the apex of which in European forms is ventral and in American varieties is dorsal to the median line of the lateral aspect. Further, the crested variety, as it occurs in Europe, approaches other European species, such as *D. kahlbergiensis*, while our recurved variety is very similar to *D. retrocurva*, the American representative of *D. kahlbergiensis*.

Range of Variation in One Locality. — In two localities only did this earlier material reveal the occurrence of more than one variety. In Lake Mendota two types may be distinguished, one closely resembling *D. gracilis*, the other the extreme round form of Lake Winnebago. Minocqua furnished forms approaching three widely differing types of development: (1) rounded crest, carried out into a sharp point; (2) extremely recurved apex; (3) triangular head with decided prominence over eye. Further examination, however, reveals a much wider range of variation for the single lake.

In the summers of 1896, 1897, and 1898, collections were made from a limited region in southeastern Wisconsin, known as the lake district of Waukesha County, and including about fifty lakes varying in size from the merest pond to those four or five miles in length and thirty meters deep. Thirty-five lakes were visited in all, most of them several times, but only fourteen of these have, up to the present time, yielded material in sufficient abundance for comparative study.

With a single exception these lakes furnish no new types, but in some lakes a single type with slight deviations is present, while others yield what might be considered distinct types, were it not for the occurrence of all imaginable transitions. This

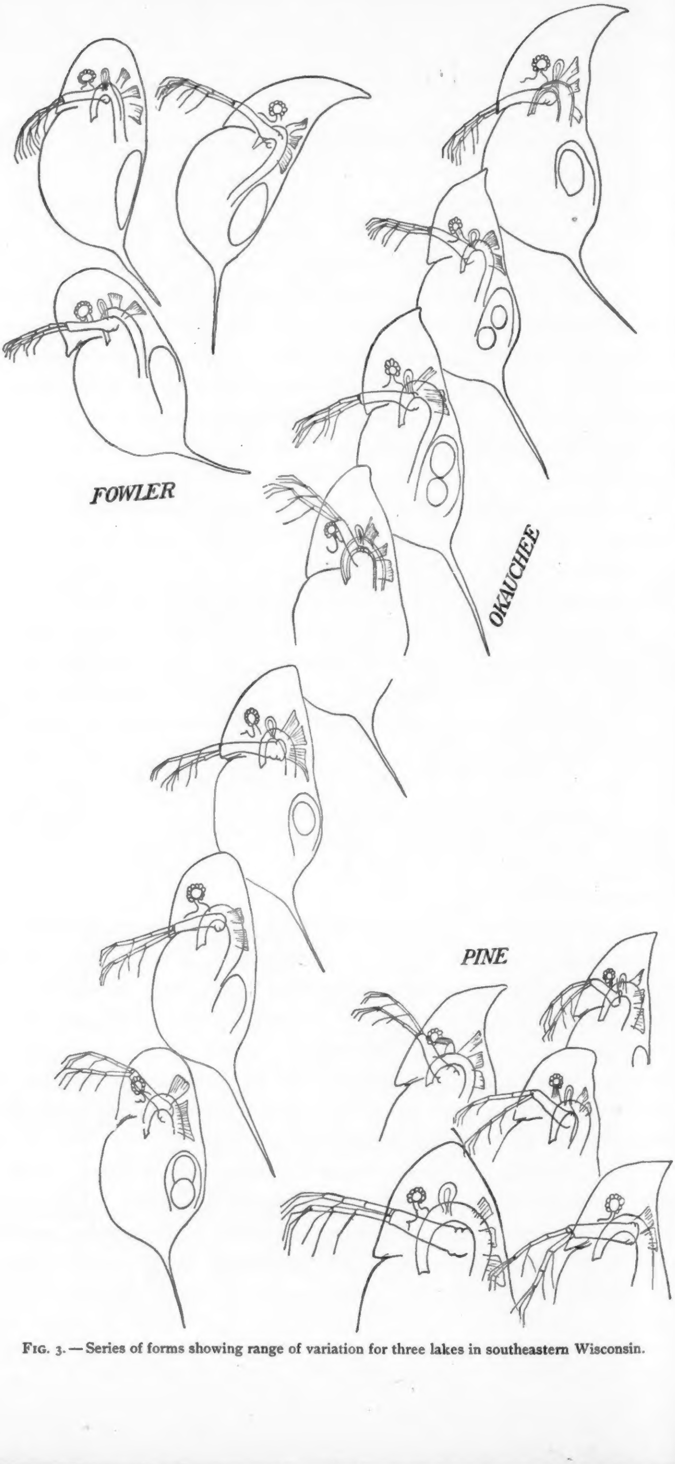

FIG. 3.—Series of forms showing range of variation for three lakes in southeastern Wisconsin.

is best shown by the accompanying series (Fig. 3), obtained in each case from single collections from Pine, Okauchee, and Fowler Lakes. It will be observed that in the two former every transition exists, from the low, evenly rounded to the extremely recurved and elongated crest, and the two series are seen to include all the American forms described, excepting perhaps the extreme of the triangular and the high-rounded types of development.

The amount of these variations was not uniformly great in all the lakes studied, nor for all the seasons in which collections

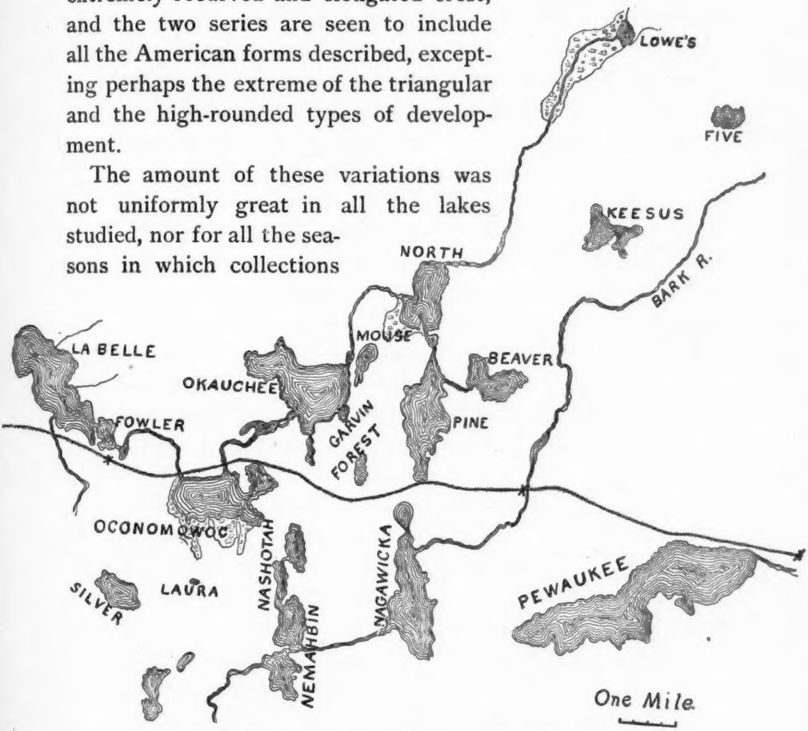

FIG. 4.—Map showing distribution of forms in southeastern Wisconsin. Taken from U. S. Topographical Survey. Lakes Laura and Garvin inserted by writer.

were made. Thus, several collections taken from Beaver, one summer, showed the prevalence of a high-rounded crest with slight tendency to antero-dorsal angulation, while the following summer many crests exhibited a distinctly recurved apex. Lake Garvin, which communicates with Lake Okauchee by means of a channel having an approximate width of fifteen feet and depth of six feet, nevertheless appears to retain a

distinct type of crest. Lake Laura, in the immediate vicinity of Okauchee and Oconomowoc Lakes, and Lowe's Lake, which lies in the same system with these, show a uniform low-crested variety, while Lakes Five and Mouse exhibit the high-rounded type of crest, with marked subocular prominence. The accompanying map (Fig. 4) shows the greater part of the area in which these forms are distributed. The lakes of the Bark River system were very poor in Crustacea and furnished almost no Daphniæ.

Seasonal Variation. — More striking still is the fact that this range of variation is confined to the summer forms. Of course, owing to the difficulty of obtaining material in the winter, no very extended study of the winter forms has been made, but Professor Birge has for years made collections of winter forms from Lake Mendota, and I have his permission to state that they are uniformly low crested, while my own study of the winter forms of Lake Oconomowoc and Okauchee gives identical results. When it is remembered that the summer broods of Daphnia are produced parthenogenetically, the determination of the kind and conditions of variation must have an important bearing on questions of heredity and the origin of specific differences.

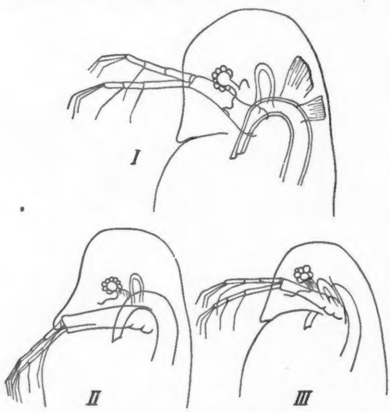

FIG. 5. — I, Lake Five; II, Mouse; III, Lowe's Lake form.

Correlations in Variability. — Although no quantitative study has yet been undertaken, careful comparison shows a direct relation between the length and curvature of the crest and the length and curvature of the terminal spine. The basal joint of the antennæ also varies, in size and strength, with the form and size of the shell. An attempt has also been made to relate the form of the crest with some

character of the environment, such as depth and size of lake, temperature, etc., but thus far the attempt has been unsuccessful. Lakes widely different in character, such as Mendota and Winnebago, possess very similar forms, while some small shallow lakes produce such extremes as those of Lakes Laura and Henrietta (Fig. 6.) Again, the occurrence of a particular variation appears to bear some relation to the forms with which it is called upon to compete. Birge ('97), considering the occurrence of *D. hyalina* and *D. retrocurva* in Lake Mendota, states that one declined in numbers according as the other increased, and concludes this to be the result of active competition between the two species. My own much more limited observation indicates a competition in which certain variations are favored to the detriment of others. A more exact study of the quantitative differences, as well as a careful investigation of the environmental influences, will be made before we attempt to show the significance of these variations; but I think the facts as here given may serve to indicate the range of interesting problems offered by a generally accessible but little known form, and thus, perhaps, invite a more extended inquiry into the condition of the species in other localities.

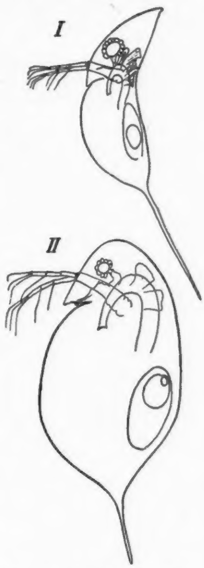

FIG. 6.—I, Form from Lake Henrietta; II, Lake Laura.

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HULL ZOÖLOGICAL LABORATORY,
November 28, 1899.

DOUBLE LOXOSOMÆ.

W. S. NICKERSON.

WHILE investigating the structure of *Loxosoma davenporti* several abnormal specimens came under my observation. These, five in number, are all double monsters, and in all cases the paired individuals are united in the same manner — side to side ; the oral surfaces are turned in the same direction, and the stalks are so united as to have a common foot. Three of

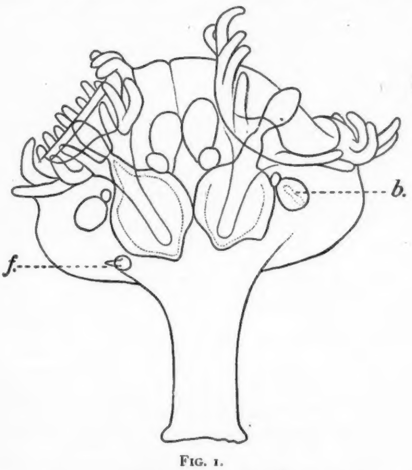

FIG. 1.

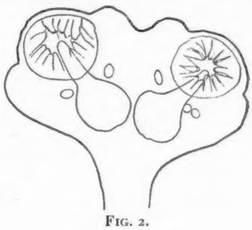

FIG. 2.

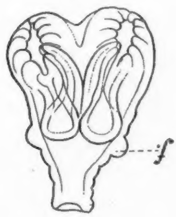

FIG. 3.

FIG. 1. — Anterior aspect. 18 and 19 tentacles. *b.* = bud ; *f.* = flask organ. × 57.
FIG. 2. — Anterior aspect. 16 and 15 tentacles. × 57.
FIG. 3. — Anterior aspect. 11 and 12 tentacles. *f.* = Anlage of flask organ. × 114.

the specimens are fully grown ; the other two are immature, one being a bud still attached to the parent, and the other, though detached when found, was even less developed, and had undoubtedly been separated from the parent by the handling it had undergone in preservation.

These cases represent three different degrees of union between individuals. Three of the cases, one adult (Fig. 1)

and two buds (Figs. 2 and 3), present essentially the same condition. In these a common stalk bears two bodies united side to side, each with its own lophophore, reproductive organs, digestive system, nerve center, and budding zones. In serial sections of the adult (Fig. 1) I have not detected any essential modification of the individual organs. All four of the gonads are ovaries. The two immature buds (Figs. 2 and 3) I have studied only as entire objects, but could discern no abnormalities in the different organs.

A second degree of union is shown by the specimen represented in Fig. 4. Here only the lower parts of the stalks are

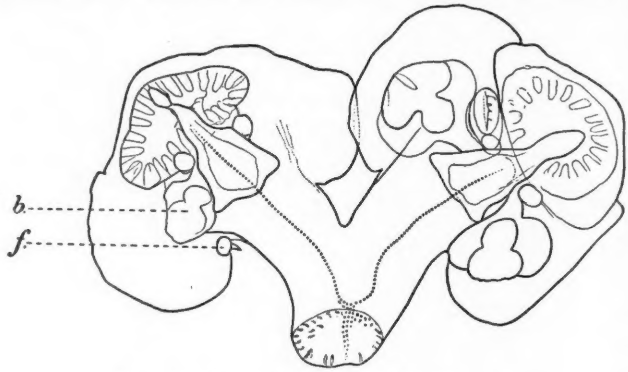

FIG. 4.—Dorsal aspect. *b.* = bud; *f.* = flask organ. × 57.

joined, so that, while the two animals have a common foot, all portions of their bodies above the middle of the stalks are quite separate and normal. The only abnormality observed in individual organs is in the arrangement of the cells of the dorsal row (Fig. 4). Where those of the two individuals come together in the fused stalk near the foot, three rows of the cells instead of two are present for a short distance, and there are slight irregularities in the arrangement of the cells.

A third condition, represented in Fig. 5, shows a greater degree of modification of the individuals and requires a more detailed description. The stalk is simple and in no way different from that of a single individual. From the body arise two lophophores, which are quite normal, and bear respectively

eighteen and twenty tentacles. In the parts located in the body, abnormalities occur in digestive, reproductive, and nervous systems. The position and arrangement of the buds is also peculiar.

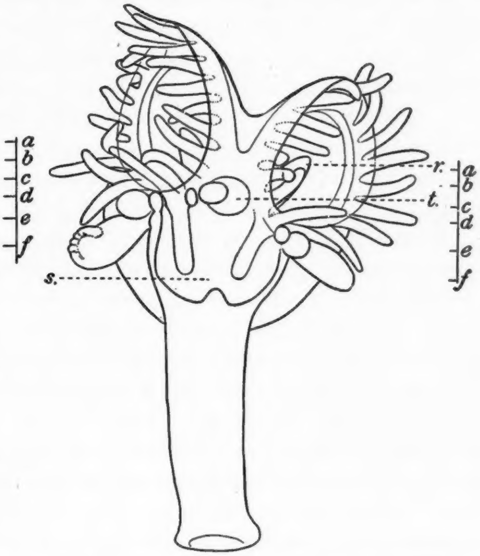

FIG. 5. — Anterior aspect. 20 and 18 tentacles. *r.* = rectum; *s.* = stomach; *t.* = testis. × 57.

The digestive tract consists of a single bilobed stomach, into which lead two gullets, and from which lead two intestines, one gullet and one intestine having the normal relation to each lophophore.

The sexual organs consist of three testes, one median above the stomach somewhat larger than the others, and one on the outer side of each œsophagus. A pair of seminal vesicles, one on either side of the median testis, open to the exterior in normal positions with respect to the two lophophores. From each of the lateral testes a duct communicates with the adjacent vesicle. The median testis has an opening into the left-hand seminal vesicle, but I have been unable to detect one to that on the right side, though the two organs lie close together, their cavities separated only by a membrane.

FIG. 6. — Outline of brain made by superposing successive transverse sections. × 250.

The brain has the form shown in Fig. 6, the median portion being somewhat higher than the ends and directly above the

median testis. A nerve bundle passes off from each end as from a normal brain.

There are eight buds arising from three budding zones. The two lateral of these zones bear each three buds, the unpaired zone having but two. These latter have the normal relation to the right-hand œsophagus and lophophore, and are unrelated to those of the other side. I have not succeeded in making out the relations of the excretory organs in this case.

It should perhaps be noted that in each of the adult double monsters (in which the gonads are developed) the paired individuals are of the same sex (Figs. 1 and 4♀, and Fig. 5♂).

None of the buds developed upon any of the double monsters is double or in any way abnormal. The condition therefore appears to be not heritable.

Two hypotheses may be offered in explanation of the facts given. According to one, the conditions found represent three different stages in a process of longitudinal fission. According to the other hypothesis, which I believe to be the correct one, they have resulted from the incomplete separation of two masses of germinal tissue, destined under normal conditions to give rise to two distinct buds. Each individual of the pair represents the resultant of the tendency toward normal development modified by the hampering influence of the adhering mass of tissue. Each double monster is therefore the result of a compromise between the two conflicting bud Anlagen. There seems to be no good ground for comparing the double monsters of Loxosoma and the double embryos normally produced sexually in the phylactolæmatous Bryozoa.

In opposition to the first hypothesis is the fact that the union between the paired young buds (Figs. 2 and 3) is no more intimate than that between the adults shown in Fig. 1, and is less intimate than that between those shown in Fig. 5. If fission were taking place we should expect the older individuals to show the later stages of the process.

Two facts tend to support the second hypothesis : (1) the position of the individuals of the pair with respect to each other is side to side, as would naturally result from the union of adjacent bud Anlagen ; (2) in all the cases (four) in which

it has been possible to determine the number of tentacles they have been found unequal on the two lophophores ; one of these is therefore in each case more advanced in development than the other, as is always the case with two buds which arise side by side, the degree of difference being, moreover, such as our hypothesis would lead us to expect.

In the specimen represented in Fig. 5 the brain and the stomach correspond in each case to two organs fused. The median testis may likewise owe its larger size to its being the result of fusion of two testes; but whether that be the case or not, its outlet is on the side of the younger individual. The mesial budding zone which has been suppressed or remained undeveloped is that of the younger individual. The latter fact harmonizes well with the theory of fusion, since when two buds come into conflict in their development the younger naturally suffers most. The relations of the median testis, on the other hand, can hardly be considered as lending support to either hypothesis.

Fission seems inherently improbable in so highly organized an animal as Loxosoma, while against the theory of fusion no such objection holds.

University of Minnesota,
July 5, 1900.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Notes on Recent Fish Literature. — In the *Proceedings of the Zoölogical Society of London* for 1899 (Pt. IV, p. 956, 1900) Mr. G. A. Boulenger records reptiles and fishes collected by John Whitehead in Hainan. The following are described and figured as new: *Corcoperca whiteheadi, Gymnostonius lepturus, Barilius hainanensis.*

In *Annales and Magazine of Natural History* (Ser. I-V, No. 26, p. 165) Boulenger describes three new species of Siluroid fishes, from the streams of São Paulo, near Santos, Brazil. These are: *Plecostomus heylandi, Loricaria latirostris,* and *Loricaria paulina.*

In the *Zoologischer Anzeiger* for June 14, 1900, Hector F. E. Jerngersen, of Copenhagen, gives a study of the urogenital organs of *Polypterus bichir* and *Amia calva.*

In the records of the Expedition Antarctique Belge, M. Louis Dollo, of the museum at Brussels, describes a new deep-sea fish of the family of Chænichthyidæ under the name of *Racovitzia glacialis,* an ally of Gerlachea and Cryodraco, already described by him. Incidentally he calls attention to the fact that the name of the deep-sea genus of *Macruridæ, Moseleya,* is preoccupied by Moseleya Quelch, 1884, a genus of corals. The genus of fishes may stand as Dolloa, *nom gen. nov.*, and its typical species as *Dolloa longifilis.* In another paper of similar date Dollo describes as new *Macrurus lecointei,* also from Antarctic depths. In the recent subdivision of this group this species would be placed in the genus Dolloa. It may stand as *Dolloa lecointei.*

In the *Proceedings of the Washington Academy of Sciences* (II, 161), Dr. Charles H. Gilbert records the fishes collected by Arthur W. Greeley as a member of the Branner-Agassiz expedition to Brazil. Eighty-five species were obtained, four of them being described and figured as new. These are: *Upeneus caninus,* from Pernambuco; *Apogon brasilianus,* from Mamanguape Reef; *Sphroides greeleyi,* from Maceio, and *Brannerella brasiliensis* from Maceio. Brannerella belongs to the Clininæ, being near Starksia, differing in the detached

first anal spine and the lack of notch on the spinous dorsal. Dr. Gilbert reduces the list of doubtful species by relegating *Eupomacentrus diencæus* to the synonymy of *E. fuscus*, *Iridio kirschi* to the synonymy of *I. poeyi*, and *Gerres embryx* with *Gerres brasilianus* to the synonymy of *Gerres lineatus*. *Chloroscombrus ectenurus* and *Labrosomus xanti*, species hitherto considered doubtful, are regarded as well established.

In the *Transactions of the Royal Society of Canada* (1899, p. 141), Dr. Philip Cox presents a list of the fishes and Batrachians of Gaspé, Quebec, with notes on their distribution. He finds the species known as *Couesius plumbeus*, *C. dissimilis*, and *C. greeni* very closely related, and suggests their probable identity, at the same time describing two forms of *C. plumbeus*, which he calls varieties. These species will bear further study, the present arrangement being wholly provisional.

In the *Records of the Australian Museum* (1900, p. 193), Mr. Edgar R. Waite makes a number of interesting additions to the fish fauna of Lord Howe Island. These species are described as new: *Amphiprion latezonatus*, *Holacanthus conspicillatus*, *Holacanthus semicinctus*, and *Euchilomycterus quadradicatus*. Euchilomycterus is a new genus of Diodontidæ, having the anterior dermal spines four-rooted. The name Acanthocaulus is suggested as a substitute for Prionurus, preoccupied by Prionurus Ehrenberg, 1829, a genus of spiders. The original date of Prionurus Lacépède is set down as 1830, but its original publication dates from prior to 1828, when it was mentioned by Cuvier. It is therefore earlier than Prionurus Ehrenberg, which is given as 1829. The interest shown by Australian naturalists in their rich fish fauna is most commendable. It is to be hoped that it may crystallize soon in a general manual of Australian ichthyology. I may note that the description of *Gempylus serpens* by Jordan and Evermann, noted by Waite (p. 199), was copied from previous authors, the authors having no specimen in hand.

In the *Records of the Australian Museum* (1900, p. 210), Mr. Edgar R. Waite, of Sydney, records a collection of fishes, mostly from Fremantle, Western Australia, in the Museum of Perth. A new species of Oplegnathus is described under the name of *Hoplegnathus woodwardi*, with an interesting discussion on the difficulties which a man in the field encounters in dealing with scanty literature,

more or less inaccessible and most of it closet made. So far as the reviewer can see, *O. woodwardi* is a valid species. It is well figured by Mr. Waite.

In the *Revista do Museu Paulista*, Dr. Carl H. Eigenmann and Allen A. Norris record (in Portuguese) species of fishes collected by Dr. H. von Ihering about Santos, in the Province of São Paulo. The following are described as new: *Nannoglanis bifasciatus*, *Imparfinis piperatus*, *Gœldiella* (*eques*) (new genus), *Iheringichthys* (*labrosus*), *Bergiella* (*westermanni*), *Perugia* (*agassizii*), *Parodon tortuosus*, *Tetragonopterus multifasciatus*, *Catabasis acuminatus*, *Myletes tieté*. Of the new genera, Imparfinis is an ally of Rhamdiella, and Catabasis of Salminus. The others are based on known species.

Dr. Carl H. Eigenmann sums up his researches on the degeneration of Amblyopsidæ and the reaction of blind-fishes to light in a lecture before the Marine Biological Laboratory at Woods Holl, published by Ginn & Company (1900). He regards the bleaching due to absence of light as an acquired character which is now fully inherited. "It is evident that in Amblyopsis we have the direct effect of the environment on the individual hereditarily established."

In the *Anatomischer Anzeiger* (XVII, p. 313), Professor George H. Parker has a valuable study of the blood vessels of the heart of the headfish or sunfish (*Mola mola*). He finds that, unlike most bony fishes, this species has retained in part the complex structures found in the Elasmobranchs, without the simplification or degradation seen in the ordinary bony fishes. When anatomists realize that not all bony fishes agree even in important characters, they will not so generally confine their studies in fish anatomy to the primitive end of the fish series. There is no more open field in science than that of the structure and development of the different groups of Teleost fishes.

D. S. J.

The "Tierreich" Sporozoa.[1] — The work opens with a summary of abbreviations of technical terms and one for the literary references, together with a systematic index. The taxonomic survey of the various genera and species of the group, which occupies the major portion of the book and follows the general plan employed in the publication as a whole, is complete and better illustrated than some previous numbers. After this comes a list of hosts, which embraces

[1] Labbé, Alphonse. *Sporozoa. Das Tierreich*, 5. Lieferung. Berlin, Friedländer, 1899. xx + 180 pp., 196 figs.

more than six hundred species in every branch of the animal kingdom and which shows clearly by the number of entries — 91 under Vermes, 121 under Hexapoda, 95 under Pisces, and 93 under Aves — what groups are particularly infested by these parasites. An alphabetic index of genera and species completes the work. The fact that, as entered on the last page, the manuscript was closed in December, 1897, while the title-page bears the imprinted date of July, 1899, goes far to explain certain shortcomings in the work, for our knowledge of this group has been particularly widened by some very recent contributions. An additional difficulty in the treatment of these forms is to be seen in the record of 94 known and 29 doubtful genera, embracing 239 certain and 259 doubtful species, as given by the author at the opening of the systematic part.

The system employed by Labbé is as follows:

I. Legion Cytosporidia (spore wanting or without polar capsules).
- 1. Order Gregarinida (sporulation not intracellular).
  - *A*. Suborder Cephalina.
    - *a*. Tribe Gymnosporea.
    - *b*. Tribe Angiosporea.
  - *B*. Suborder Acephalina.
- 2. Order Coccidiida (sporulation intracellular; no motile free stage in adult form).
  - *A*. Suborder Polyplastina (many archispores).
    - *a*. Tribe P. digenica.
    - *b*. Tribe P. monogenica.
  - *B*. Suborder Oligoplastina (few archispores).
    - *a*. Tribe Tetrasporea.
    - *b*. Tribe Trisporea.
    - *c*. Tribe Disporea.
- 3. Order Hæmosporidiida (sporulation intraglobular).
- 4. Order Gymnosporidiida (adult amœboid; no cyst).

II. Legion Myxosporidia (spores with polar capsules).
- 1. Order Phænocystida (polar capsules distinct).
- 2. Order Microsporidiida (capsules invisible in life).

Sporozoa *incertæ sedis:* Sarcosporidia,
Amœbosporidia,
Serumsporidia.

A number of genera, including Amœbidium, Piroplasma, and Babesia, are listed as Sporozoa *incerta*, while Coccidioides and the pseudo-Coccidia are included in an appendix.

It is not to be expected that a group including so many poorly known forms and so many species, genera, and even possible orders,

whose relations are uncertain and concerning whose life history nothing has yet been ascertained, could be satisfactorily monographed at this time. Even the brief interval which has intervened since the completion of the book has furnished positive evidence that certain genera, Eimeria and Pfeifferella, are merely developmental stages in the evolution of other forms, a relation which, by the way, is noted as a possibility in the description of some species in the text. With this the entire tribe of *Polyplastina monogenica* probably disappears, as the species are incorporated into the life history of others in the *P. digenica*. Similarly, in the Oligoplastina the single species of Trisporea is but a chance variation of the usual four-spored condition of that form, and thus another tribe falls out.

The two orders of Hæmosporidiida and Gymnosporidiida are distinguished by the presence of a gregarine stage and of a cyst in the former, and by their absence in the latter. Recent discoveries on the life history of the malarial parasite have shown that this distinction will not hold, and apparently the two orders are much nearer together than most of the families given in the synopsis. In the classification of the Myxosporidia, Labbé has followed Thélohan very closely and has attained a less artificial system than that of Gurley. Under the Sarcosporidia, however, the result is less satisfactory, and in the present ignorance concerning these forms it is not clear that anything has been gained by the suppression of Blanchard's genera, Miescheria and Balbiania, a movement in which the author is not likely to be followed at present, at least.

A considerable number of changes in generic and specific names were necessary where the earlier names were preoccupied; it may be questioned, however, whether changes in spelling, *e.g.*, Plistophora for Pleistophora Gurley, do more than add to the already heavy burden of synonyms. Among familiar names which have been supplanted necessarily may be noted Glugea, antedated by Nosema, Proteosoma by Hæmoproteus, and Drepanidium preoccupied and replaced by Lankesterella. In glancing over the list of genera current among the Sporozoa one cannot help being struck by the dedicational-phobia which has afflicted students of the group!

Among the large number of uncertain genera and species listed, some are capable of being precisionized: thus, of the fifteen doubtful species of Gregarinida briefly described by Leidy, the unpublished drawings for his monograph on the group are still in existence and, it is to be hoped, may be published with satisfactory descriptions. Others of the *sp. inq.* are yet under discussion and will ultimately be

placed; but many of the references are mere rubbish and should be noted as such, to save the labor of future students. Thus, the uncertain genus, Molybdis Pachinger, has been shown by Braun to be in all probability based on eggs of *Distomum turgidum*, and yet no note of this fact appears in the text. If all references to supposed members of the group are to be included, reference should have been made to *Coccidium pylori* Gebhardt, a species founded on a similar confusion. The listing of such forms without explanation entails endless labor on those not familiar with the details of the particular case, and reference should be made under doubtful forms to all such explanations, whether accepted by the monographer or not.

Some instances were noted of opposite conclusions in cases involving very similar conditions. Thus, the author accepts two genera, Hæmoproteus and Halteridium, for the parasites of the avian red-blood corpuscles, but reduces similar forms of man, not only to one genus, but even to varieties of a single species! Some of the differences given to the first-named genera in the text, it should be noted, have never been confirmed since the original observations of Labbé on these forms. Again, he accepts the genus Goussia on the basis of a trivial difference in the form of the sporocyst, but rejects Benedenia as an independent genus, though it differs radically in number of sporozoites produced. Recently discovered differences in life history make the distinctness of this genus unassailable.

Withal, these are minor criticisms; Labbé has traversed nearly untrodden ground. It is not surprising that the results are most satisfactory on best-known territory, *e.g.*, Gregarinida, and weakest in those groups, such as the Coccidiida and Hæmosporidiida, which are not only least known, but which are now the object of careful study at many hands. The work of the author is very complete and is a mine of useful information for workers on this group; remarkably few references are lacking, and only a simple misprint was noted. The figures also are well selected and, for the most part, well reproduced.

HENRY B. WARD.

Faune de France.[1] — Half a century ago this work would have been accepted as very good; to-day it is out of date in classification, in method, and to some extent in illustration. The classification shows little improvement on that of Cuvier. The method is synoptic; in the special synopses the points of comparison are most often

[1] Acloque, A. Faune de France. *Les Poissons, les Reptiles, les Batraciens, les Protochordes*. Paris, Baillière, 1900. Pp. 209, 12mo, illustrated.

well chosen, but they are too few in number; though the data may serve to eliminate all but one of the species compared, they are insufficient to identify that one, with any degree of confidence, in modern definitions of species, varieties, etc., or in view of possible intrusions of outside species. The book was compiled mainly from literature; the illustrations drawn from Moreau and Blanchard are tolerably good, but the few drawn from nature painfully indicate the author's lack of familiarity with his subject. Some of these figures are mere caricatures: for examples, the codfish, *Gadus morrhua; Scomberesox saurus, Belone vulgaris,* among others, or the figure of *Spinax niger,* which resembles no known shark. Various figures of dentition show nothing of the basal portions of the teeth. Borrowed illustrations are credited in this way: "*Spinax niger* (E. Moreau)"; this would mean to naturalists generally that E. Moreau was the authority for the specific name, niger. Not all of the species are included.

Notes. — C. M. Fürst (*Anat. Anzeiger*, XVIII, 190–203) has investigated the finer structure of the hair cells in the ear of the salmon. Each hair cell carries a brush of hairs projecting beyond the limits of the cell. The enlarged bases of these hairs give rise to a disk-shaped body just within the cell wall. From this disk a cone-shaped mass extends into the interior of the cell. From the staining qualities of these parts the author concludes that the brush of hairs represents cilia whose basal bodies have united to form the disk-shaped mass, and whose cone organ is represented by the cone-shaped body. In other words, sensory hair cells have the morphological peculiarities of ciliated cells.

The richness of the entomological collections of the Oxford University Museum is well illustrated by Swinhoe's recent volume.[1] Two thousand three hundred species are listed; the Noctuina, Geometrina, and Pyralidina by Swinhoe, the Pterophoridæ and Tineina by Walsingham and Durrant. Many new genera and species are described, and the synonymy and bibliography are given *in extenso.* In method of citation and typographically the pages contributed by Walsingham and Durrant differ from those of Swinhoe; Ægeriadæ, Gelechiadæ, are contrary to the best usage. The work is published in the handsome form characteristic of the Clarendon Press. The eight beautiful plates figure, chiefly, species imperfectly described by Walker.

[1] *Catalogue of Eastern and Australian Lepidoptera Heterocera*, Pt. II. Oxford, 1900. viii, 632 pp., 8 plates.

In the *Proceedings of the Manchester Institute of Arts and Sciences*, Vol. I, 1899 (1900), Mr. E. J. Burnham gives an annotated list of twenty-eight species of Anisoptera taken in the vicinity of Manchester, N. H. To the same publication, and also from the vicinity of Manchester, Miss Susy C. Fogg contributes a list of thirty-five Orthoptera.

In *Novitates Zoologicæ*, Vol. VII, No. 2, August, 1900, Warren describes more than two hundred and forty new species of Drepanulidæ, Thyrididæ, Epiplemidæ, and Geometridæ from South and Central America. More than three-fifths of these new species are described from uniques, and of the others only a few are represented by adequate series.

K. W. Verhoeff (*Zool. Anzeiger*, Bd. XIII, p. 465) reports that railroad traffic in the neighborhood of Sennheim in Alsace has been seriously interfered with by a swarm of myriapods (*Schizophyllum salulosum*) crossing the tracks in a wooded district. The crushed bodies of the animals rendered the rails so slippery as to impede seriously the progress of the trains. The animals were sexually mature males and females, and their migration was caused, the author believes, by over-population, whereby egg-laying was made unfavorable.

A. Dendy (*Zool. Anzeiger*, Bd. XXIII, p. 509) points out that the females of three of the Australian species of Peripatus are provided with well-developed ovipositors, and that two of these species, and possibly the third, lay eggs, a habit unknown in the other species of Onychophora. This justifies, in the author's opinion, the erection of a separate genus for the reception of these three species, and for which the name Oöperipatus is proposed.

Professor Keibel's Normal Tables for the Development of the Vertebrates, of which the first part, published some three years ago, dealt with the pig, have been extended in the recently published second part to the chick (Normentafel zur Entwicklungsgeschichte des Huhnes, von Prof. Dr. F. Keibel und K. Abraham. 1900).

The third part of Oppel's Lehrbuch der vergleichenden mikroscopischen Anatomie der Wirbeltiere has just made its appearance and contains an account of the mouth cavity, liver, and pancreas. In size and number of illustrations this part is somewhat larger than the combined first and second parts, which together deal with the œsophagus, stomach, and intestine.

No. 5 of Vol. IV of the *American Journal of Physiology* contains the following papers: "On the Physiological Action of the Poisonous

Secretion of the Gila Monster (*Heloderma suspectum*)," by J. Van Denburgh and O. B. Wight; "A Study of the Effects of Complete Removal of the Mammary Glands in Relationship to Lactose Formation," by B. Moore and W. H. Parker; and "Brief Contributions to Physiological Chemistry," communicated by L. B. Mendel.

BOTANY.

Briefer Courses in Botany. — In the making of text-books two more or less conflicting tendencies come to the surface — that to reasonable completeness and symmetry of treatment, and that to due brevity. Nearly every general text-book of the past decade or more, if it has met with favor, has appeared shortly in an abridged form. The latest of these abbreviated books are Atkinson's *Lessons*,[1] Barnes's *Outlines*,[2] and Coulter's *Plant Studies*;[3] and each represents virtually a one-term text-book based on the earlier full-year books by the same authors. In the main, the characteristics of the latter pertain to them in their shorter form. Each author approaches his subject from his own point of view, and what has been said in earlier numbers of the *Naturalist* about the fuller books need not be repeated here for the abbreviated editions. A pamphlet of suggestions to teachers, by Dr. Caldwell, accompanies Part II of the fuller edition of Coulter, — *Plant Structures*, — and, while it is not above criticism, is likely to assist even the trained teacher in many small ways. T.

Nicholson's Dictionary of Gardening.[4] — Simultaneously with the appearance of Professor Bailey's *Cyclopedia of American Horticulture*, of which two volumes have already been noticed in the *Naturalist*, comes a supplement to its great predecessor, Nicholson's *Dictionary*, which a competent authority characterized in its day as the best reference book within reach of the gardener and fruit-grower, and a model

[1] Atkinson, G. F. *Lessons in Botany*. New York, Henry Holt & Co., 1900.

[2] Barnes, C. R. *Outlines of Plant Life, with Special Reference to Form and Function*. New York, Henry Holt & Co., 1900.

[3] Coulter, J. M. *Plant Studies*. An Elementary Botany. New York, D. Appleton & Co., 1900.

[4] Nicholson, G. The "1900" Supplement to the *Dictionary of Gardening*, a practical and scientific encyclopædia of horticulture for gardeners and botanists. Hyde Park, Mass., Geo. T. King, 1900. *A* to *F*. 4to, pp. viii + 376, ff., 385, with several colored plates. Price $5.00.

of its kind. Nearly twenty years have elapsed, however, since the work was published, and progress has been both varied and rapid in gardening, so that it is a matter for congratulation that Mr. Nicholson, the well-known curator of the Kew Gardens, has found time to prepare a supplement bringing it up to date. This supplement is to consist of two volumes, of which the first, bearing a preface date of June, 1900, is already in hand. To say that the supplement equals, if it does not surpass, the original volumes is sufficient to indicate that in text and illustrations it is excellent. While for American gardeners Bailey's *Cyclopedia*, being an American work, is likely to be more directly useful, the fact that its scope is limited to this country makes the possession of the Nicholson *Supplement*, as well as the original *Dictionary*, all the more necessary for the larger establishments, which are constantly introducing the better of the plants grown abroad, and for all amateur libraries. T.

James's Practical Agriculture.[1] — The author has embodied in this work the most elementary principles and practical applications of agricultural science in a very pleasing manner. It is especially well adapted as a text-book for beginners in the study of agriculture, and is certainly an impetus for the more general introduction of the subject in the public schools. Agriculture embraces such a broad field, it is impossible to treat elaborately each branch in a text-book of the ordinary size. While these first principles are concisely treated, they are nevertheless clear and accurate, and easily understood by persons not familiar with the study of botany, geology, or other sciences that have to do with agriculture.

The life cycle of a plant is traced from the seed to the mature plant, including both structure and essential conditions of germination and growth. The nature, origin, and improvement of the soil and its relation to the plant are discussed. One part is devoted to various field crops, taking up grasses, legumes, root crops, etc., giving the nature, habit, and treatment of each and the reasons therefor. Another part considers horticulture and its products, including the vegetable garden, orchard, and vineyard. The habits of many of the most common insects and fungous diseases of both field and garden are discussed. Live stock and its product, milk, receive some attention, as well as the history and characteristics of different breeds.

H. C. IRISH.

[1] James, Charles C. *Practical Agriculture.* American edition by John Craig. D. Appleton & Co., 1900.

Notes. — Several handbooks of photographic illustrations of the famous Kew Gardens have been placed on the market and form attractive souvenirs of a visit to the charming suburb of London, in which the gardens are situated. The latest of these (E. J. Wallis, *Illustrations of the Royal Botanic Gardens, Kew*, from photographs taken by permission, London, 1900), with half-tone plates 5½ × 6½ in., is prefaced by a laconic note by the Director, Sir W. T. Thiselton-Dyer, who has also written a few words of description of each of the pictures.

Professor Boppe, director of the forestry school of Nancy, with the aid of his associate, M. Jolyet, has brought together in book form the substance of his course of lectures in that institution, illustrating it by a number of instructive, if not always well-done, views, indicating landscapes, plantations, and methods (L. Boppe and A. Jolyet, *Les Forêts; Traité pratique de sylviculture*, 8vo, pp. xi + 488, ff. 95, Paris, Baillière, 1901).

Professor Saunders's extensive experimental tests of woody plants in the British territory to our north are further evidenced by a catalogue of fruit trees under test at Agassiz, British Columbia, published as *Bulletin No. 3*, second series, of the Central Experimental Farm at Ottawa, in which 1217 varieties of apples, 36 of crabs, 557 of pears, 311 of plums, 154 of cherries, 213 of peaches, 53 of apricots, 25 of nectarines, 12 of quinces, 7 of medlars, and 6 of mulberries are included. The recommended varieties are: apples 20, pears 10, plums 10, cherries 11, and peaches 5.

Rev. Arthur C. Waghorne, who, while engaged as a pastor in Newfoundland, has made extensive collections representing the flora of that island during the past decade, died recently in Jamaica, where he went early in the season in the hope of recovering from disease incurred in the performance of his trying duties, which not infrequently involved great hardship and exposure.

Professor Marsh's residence and grounds, bequeathed to Yale University for a botanical garden, are to be made the home of the newly created school of forestry, to the direction of which Professor Toumey has been called. Illustrations of the residence are given in *The Forester* for August.

Current numbers of the *Anales del Instituto Médico Nacional*, of Mexico, contain numerous articles on the native plants of that country which are employed as domestic remedies, etc. In the number

for November last, recently issued, is an especially noteworthy illustrated article on Peyotes, by which name are known certain alkaloid-bearing species of Senecio and Anhalonium.

An index to the new genera, species, and varieties of plants described in the first twenty-five volumes of Engler's *Botanische Jahrbücher* is brought to completion in the number of that journal issued on July 13 of this year. It occupies over ninety double-column pages.

A forest fire about 2000 years ago forms the subject of an interesting article in *The Canadian Record of Science* for July, by G. F. Matthew, who obtains his information from the exploration of the contents of a recently opened bog near St. John.

An illustrated paper on the comparative anatomy of *Chlorophytum elatum* and *Tradescantia virginica*, by Gravis and Donceel, is published in Vol. II of the current series of *Mémoires de la Société royale des Sciences de Liége.*

Some of the unpublished results of the investigation of the tannins by the late Professor Trimble appear in the *American Journal of Pharmacy* for September.

The park and city flora of Detroit, comprising thirteen pteridophytes and eight hundred and forty-eight spermatophytes, is listed by O. A. Farwell in the eleventh *Annual Report* of the commissioners of parks and boulevards of that city.

Mr. Sudworth's account of the White River Plateau and Battlement Mesa forest reserves is reprinted from Vol. XX, Part V, of the *Annual Report* of the United States Geological Survey.

Professor K. C. Davis's papers on the native and cultivated Ranunculaceæ of the United States are continued in Part IV of the current series of *Minnesota Botanical Studies*, the genera Delphinum, Ranunculus, and Thalictrum being passed in review.

The West American Scientist for July contains Part V of Mr. Orcutt's "Review of the Cactaceæ of the United States."

Mr. W. A. Wheeler publishes an ecological paper on the flora of southeastern Minnesota in the most recent number of *Minnesota Botanical Studies.*

A preliminary report by Professor Hume on pecan culture, with figures of the better varieties of nuts, constitutes *Bulletin No. 54* of the Florida Agricultural Experiment Station.

A hybrid of *Quercus phellos* × *Q. rubra*, cultivated in France, is recorded by M. de Vilmorin in the *Bulletin de la Société botanique de France* for November last.

A series of half-tone illustrations of the Californian palm in its native home are published in *The Land of Sunshine* for August and September.

Tsuga canadensis pendula, as cultivated in the grounds of Professor Sargent at Brookline, is illustrated in *Möller's Deutsche Gärtner-Zeitung* of August 18.

A lecture by Dr. Francis Wyatt, on the influence of science in modern beer brewing, is published in the *Journal of the Franklin Institute* for September.

CORRESPONDENCE.

To the Editor of the American Naturalist:

SIR, — Permit me to add a few lines to the review of Garman's Deep-Sea Fishes in the August issue of *The American Naturalist*, for I feel that a work of such importance is deserving of further mention in your pages. Possibly the reviewer in speaking of it as "monumental" and "the most important ichthyological work of the past year" considered such summary praise sufficient. With this I can hardly agree, for the many who are not privileged to see the two magnificent volumes will probably fail to get a just estimate of the true character of this splendid work. That such a monograph on the deep-sea fishes should be dismissed with little more than a long list of species described seems hardly just to the work of the author and to the auspices which made its publication possible. One would not know from the review given in your journal that this report, with its more than four hundred pages of text and one hundred plates, forms Vol. XXIV of the *Memoirs of the Museum of Comparative Zoölogy*, nor that its genuinely monographic treatment of the subject has been worthily aided by the customary admirable presswork and illustrations which characterize the *Memoirs*. Two other extensive works on deep-sea fishes exist: Günther's *Challenger Report* and Goode & Bean's *Oceanic Ichthyology*. It is noteworthy that the latter also is in great part based upon the results of explorations under the supervision of Alexander Agassiz. Mr. Garman's report, while in number of pages and plates intermediate between the other two, is clearly the equal of either in every respect. It certainly should have been noted that among the plates, which are superior to any heretofore published, there are fifteen colored lithographs of deep-sea fishes giving the most perfect illustrations that have yet been produced, and one of the most important of the many contributions of the artist Westergren.

HENRY B. WARD.

UNIVERSITY OF NEBRASKA, LINCOLN,
September 22, 1900.

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(*No. 406 was mailed October 30.*)